REFRACTION and MUSCULAR IMBALANCE

AS SIMPLIFIED THROUGH THE USE OF THE SKI-OPTOMETER

SKI-OPTOMETER MASTER MODEL 215

Embodying in a Single Instrument, in Convenient Form, Cylindrical and Spherical Lenses, in Combination with Appliances for Testing and Correcting Muscular Imbalance.

Refraction and Muscular Imbalance

As Simplified Through the Use of the Ski-optometer

By
DANIEL WOOLF

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THE demands of the day for maximum efficiency in the refracting world are largely accountable for the inception, continuous improvement and ultimate development of the master model Ski-optometer.

The present volume, dealing with the instrument's distinctive operative features, has been prepared not only for Ski-optometer users, but also for those interested in the simplification of refraction and muscular imbalance.

The author is indebted for invaluable counsel, to

Louis J. Ameno, M.D., New York.
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INTRODUCTORY

WHILE in a measure the conventional trial case still serves its purpose, so much of the refractionist's time is consumed through the mechanical process of individually transferring the trial case spheres and cylinder lenses, that far too little thought is given to *muscular imbalance,* notwithstanding its *importance* in all refraction cases.

Dr. Samuel Theibold, of Johns Hopkins University, in a recent address before the American Medical Association, stated that the average refractionist was inclined to devote an excess of time to general refraction, completely overlooking the important test and correction of muscular imbalance. If the latter is to be at all considered, general refraction must be simplified—without impairing its accuracy—a result that is greatly facilitated through the use of the Ski-optometer.

One must admit that tediously selecting the required trial-case lens—whether sphere, cylinder or prism—watching the stamped number on the handle—continual wiping and inserting each individual lens in a trial frame is a time-consuming practise. This is readily overcome, however, through the employment of the Ski-optometer.

In a word, the Ski-optometer is practically an automatic trial case, bearing the same relation to the refracting room as the accepted labor and time-saving devices of the day bear to the commercial world.

The present volume has accordingly been published, not alone in the interest of those possessing a Ski-optometer, but also for those interested in attaining *the highest point of efficiency* in the work of refraction and muscular imbalance.

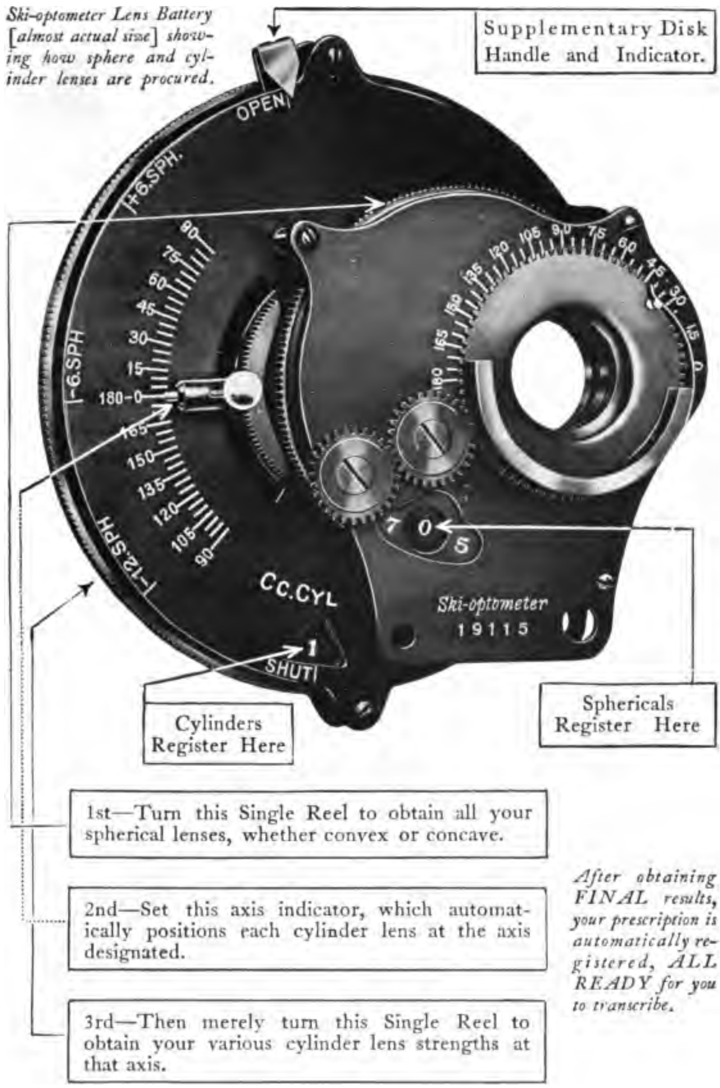


Fig. 1—The three time-saving moves necessary in the operation of the Ski-optometer.

Chapter I

SKI-OPTOMETER CONSTRUCTION

A FAR better understanding of the instrument will be secured if the refractionist possessing a Ski-optometer will place it before him, working out each operation and experiment step by step in its proper routine.

The three moves as outlined in Fig. 1 should first be thoughtfully studied and the method of obtaining the spheres and cylinders carefully observed.

Fig. 2—To Obtain Plano.

1—Set spherical indicator at "000" as illustrated above.
2—Set cylinder indicator to "0".
3—Set pointer of supplementary disk at "open".

The instrument should then be set at zero or "plano," a position indicated by the appear-

ance of the three "o o o" at the spherical register, in conjunction with one "o," or zero, for the cylinder at its register, marked "CC Cyl."

After this move, the supplementary disk's pointer should be set at "open" (Fig. 2).

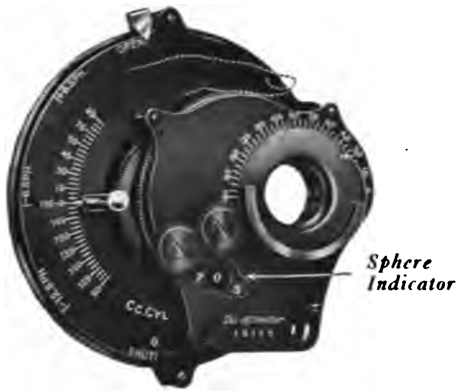


Fig. 3—To obtain sphericals, turn this Single Reel as shown by dotted finger. This assures an automatic and simultaneous registration at sphere indicator of focus of lens appearing at sight opening.

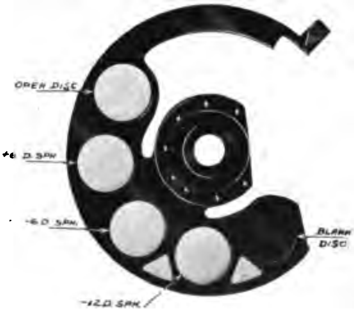
Convex Spherical Lenses

A careful study will show that the Skioptomoter's spherical lenses are obtained by merely turning the smaller reel (Fig. 3). The first *outward* turn of this reel, toward the temporal side of the instrument, draws into position in regular order the spherical lenses

+.25, +.50, +.75, and +1.D., as shown in Fig. 3a.

3-A — Outer spherical reel containing Cx. sphericals from .025 to 1.00D and a blank.

3-B — Inner spherical disk containing Cx. sphericals, automatically turns within 3-A.



3-C — Supplementary spherical disk.

By means of a concealed tooth gear, an inner disk is automatically picked up, placing its first lens +1.25D in position (Fig. 3b). This +1.25D spherical lens remains stationary while the outer disk again revolves, adding to it the original +.25, +.50, +.75 and +1.D.,

Fig. 4—With the reappearance of "00" at sphere indicator, a rapid increase or decrease of +1.25 is accurately and speedily attained.

the latter totalling +2.25D. At this point, the instrument again automatically picks up its inner disk, thereby placing its second lens, +2.50D, in position.

Instead of using intermediate strengths in making an examination, it is frequently desirable to make such extended changes as 1.25D to 2.50D. With the Ski-optometer, the refractionist will note that two white zeros appeared at the spherical register in connection with +1.25, and again with +2.50. A rapid outward turn of the spherical reel toward the temporal side to the point of the reappearance of the two zeros will show +3.75D; or, if increased power is still desired, a rapid turn will draw +5.D. into position (Fig. 4).

Turning the reel inward toward the nasal side will likewise decrease its convex power. In brief, each one of these lenses, showing their foci in conjunction with the two white zeros, are signals indicating the rapid increase or decrease of one and one-quarter diopter. After continuing to +6D., the next turn automatically shows zero (or "plano"), the original starting point, which is again indicated by the three white zeros.

Through the turn of the single reel—an exclusive Ski-optometer feature—all convex spherical lenses have now been attained in quarters up to +6.D, practically covering ninety percent of all refraction cases.

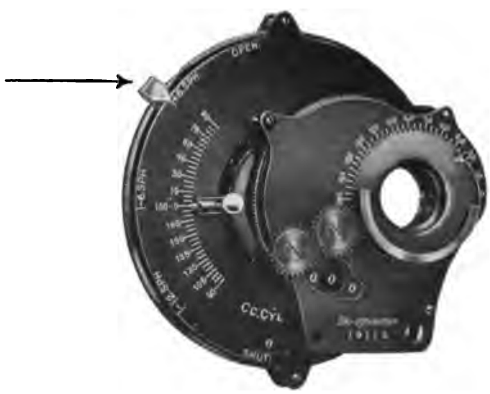


Fig. 5—With supplementary disk pointer set at + 6 Sph., this places an additional + 6.D spherical lens at sight opening, extending instrument's total convex spherical power to +12.D.

Should still greater power be desired, the small pointer at the outer edge of the instrument should be set at +6 sphere (Fig. 5). This controls a supplementary disk (Fig. 3c) which places an additional +6D. lens before the original range of lenses previously referred to, thus increasing the maximum power to +12D. If still greater strength is required, any additional trial case lens may be added, a cell being provided for that purpose on the forward plate of the instrument.

Operates and Indicates Automatically

As previously explained, in using the Skioptometer, it is only necessary to remember that each outward turn of the single reel toward the temporal side of the patient *increases* the plus power, while the reverse turn toward the patient's nose *decreases* it. In fact, no attention need ever be given the register until the required sum-total is secured, it only being necessary to turn the single reel in order to be assured of the unvarying and accurate operation of the instrument.

For convenience, the contour or upper edge of the plate covering the spherical reel has been made to fit the index finger (Fig. 3). Hence the operator should note that it requires but one complete turn from extreme side to

side, rather than a number of short turns, in order to bring each individual lens into position, thus obtaining the full advantage of the automatic spring-stop. This likewise permits the refractionist to operate the Ski-optometer even though the room is in total darkness.

Concave Spherical Lenses

Another simple and exclusive Ski-optometer advantage worthy of note is the method employed in obtaining concave, spherical lenses. Instead of employing a battery of concave lenses similar to the convex battery previously described, the instrument's operation is greatly simplified through the use of a neutralizing process.

In short, the Ski-optometer only contains two concave lenses to obtain its entire series—namely, a —6.D and a —12.D sphere (Fig. 3c)—first setting the pointer of the supplementary disk at —6. sphere, then setting the indicator of the spherical battery at +6.

Thus zero (or plano) is obtained, the plus neutralizing the minus.

By merely turning the plus or convex spherical reel inward, or toward the patient's nose, the convex power is then decreased, naturally increasing the concave value or total minus lens power. For example, if the spherical in-

dicator shows +5.D, when the —6D. lens is placed behind it, the lens value at the sight opening will be —1D (Fig. 6). If required, the refractionist may continue on this plan until only the —6D. lens remains.

Fig. 6—With this indicator of supplementary disk, set at —6.D. Sph. and spherical indicator at +5.D—lens value at sight opening is —1.D. Sph. This simple arrangement makes it possible to operate the Ski-optometer with but Single Reel for both plus and minus sphericals.

Should concave power stronger than —6D. be desired, by placing the pointer of the supplementary disk at —12D. Sph. and proceeding to neutralize as before, all the concave powers up to —12D. in quarters are similarly obtained. For the convenience of the operator, all minus or concave spherical powers are indicated in *red;* while plus, or convex powers, are indicated in *white.*

The instrument is also provided with an opaque or blank disk which is brought into position before the sight opening by setting the pointer of the supplementary disk at "shut" (Fig. 3c.)

Summing up, all plus and minus spherical powers have been attained from zero to 12D. in quarters, practically through the turn of the single reel—*a simplicity of operation largely responsible for Ski-optometer supremacy.*

Chapter II

CYLINDRICAL LENSES

IT is commonly admitted that setting each trial case cylindrical lens at a common axis is the most tedious part of refraction.

The automatic cylinder, one of the Ski-optometer's latest and distinctly exclusive features, not only overcomes this annoyance but also avoids the need of individually transferring each cylindrical lens according to the varying strengths.

Fig. 7—Once you set the axis indicator as shown by dotted fingers, each cylindrical lens in the instrument automatically positions itself exactly at that axis, as indicated by the arrow.

By merely setting the Ski-optometer's axis indicator (Fig. 7), each cylindrical lens in the instrument automatically positions itself,

so that it will appear at the opening at the *exact axis* indicated.

This is readily accomplished by placing the thumb on the small knob, or handle of the axis indicator, drawing it outward so as to release it from spring tension. The indicator may then be set at any desired axis; and, on releasing the handle, every cylinder in the instrument becomes locked, making it *impossible* for any lens to appear at an axis other than the one specified by the indicator.

This insures the *absolute accuracy* of the axis of every cylinder as it appears before the patient's eye. Subsequent shifting of the axis even to a single degree is impossible, although it is a common occurrence where trial-case lenses are employed.

Obtaining Correct Focus

After setting the axis indicator, the only remaining move is to obtain the correct cylindrical strength or focus. This is readily accomplished by merely turning the Ski-optometer's larger or extreme outer single reel, which contains concave cylindrical lenses from .25D to 2D in quarters (Fig. 8a). It should again be borne in mind that a downward turn *increases* concave cylinder power, while an upward turn *decreases* it. The oper-

ation of the cylinder reel is greatly facilitated by carefully noting position of thumb and index finger (Fig. 8). Thus accuracy of result, simplicity of operation and the saving of much valuable time is invariably assured.

Fig. 8A—Inner cog-wheel construction, showing arrangement of Ski-optometer cylinders. This simple construction assures accuracy and avoidance of the slightest shifting of axes.

As each cylinder appears before the patient's eye, it simultaneously registers its focus at the indicator marked "CC CYL" shown in Fig. 8. Examinations of greater accuracy could not possibly be made than those obtained through the Ski-optometer, hence no refractionist should hesitate to employ it throughout an *entire* examination—wherever trial-case lenses are used.

The range of the Ski-optometer's cylinder-lens battery includes up to 2D. in quarters. An axis scale and a cell is located at the back

of the instrument for insertion of an additional trial-case cylinder lens, when stronger cylin-

Fig. 8—Turn this Single Reel as shown by dotted finger to obtain cylindrical lenses, which simultaneously register their focus as they appear. Each lens also automatically positions itself at axis designated.

drical power is required. For example, if an additional —2D. cylinder is added, it will increase the range up to 4D. cylinder; or if twelfths are desired, an 0.12D. cylinder lens may be inserted. In this connection, it is interesting to note that considerable experimenting with *twelfths* in the Ski-optometer proved them to be needless, inasmuch as the instrument's cylindrical lenses set directly next to the patient's eyes overcome all possible loss of refraction, as explained in a later paragraph.

Why Concave Cylinders Are Used Exclusively

The Ski-optometer contains only concave cylinders, as it is universally admitted that convex cylinders are not essential for testing purposes.

In fact, concave cylinders should alone be used in making an examination, even where a complete trial-case is employed. To repeat one of the first rules of refraction: "As *much* plus or as *little* minus spherical power as patients will accept, combined with weakest minus cylinder, simplifies the work of refraction and insures accuracy without time-waste."

After an examination with the Ski-optometer is completed, the total result of plus sphere and minus cylinder may be transposed if desired, though in most intances it is preferable to prescribe the exact findings indicated by the instrument. This will also avoid every possibility of error, eliminating responsibility where one is not familiar with transposition—since, after all, it is the duty of the optician to thoroughly understand that part of the work.

Transposition of Lenses

It is commonly understood that transposition of lenses is merely change of form, but not of value.

For example, a lens +1.00 sph. = —.50 cyl. axis 180° may be transposed to its equivalent, which is + .50 sph. = + .50 cyl. axis 90°. The accepted formula in this special instance is as follows: Algebraically add the two quantities for the new sphere, retain the power of the original cylinder, but change its sign and reverse its axis 90 degrees. Applying this rule, a lens + .75 sph. = — .25 cyl. axis 180°, is equivalent to + .50 sph. = + .25 cyl. axis 90°.

Similarly, a lens +1.00 sph. = — 1.00 cyl. axis 180° is equivalent to +1.00 cyl. axis 90°.

One of the difficulties in transposing is in reversing the axis. In such cases, it is well to memorize the following simple rule:

To reverse the axis of any cylindrical lens containing three numerals—add the first two together and carry the last. For example, from 105 to 180 degrees, etc.:

105° Add—one and "0" equals 1	Then carry the 5 = 15°
120° Add—one and two equals 3	Then carry the 0 = 30°
130° Add—three and one equals 4	Then carry the 0 = 40°
150° Add—five and one equals 6	Then carry the 0 = 60°
165° Add—six and one equals 7	Then carry the 5 = 75°
180° Add—eight and one equals 9	Then carry the 0 = 90°

To transpose where there are but *two* numerals, 90° should be added.

In using the Ski-optometer, it is absolutely unnecessary to transpose the final result of an examination; merely write the prescription as

instrument indicates. The idea that plus sphere combined with minus cylinder, or the reverse, is an incorrect method of writing a prescription, has long since been disproved.

Chapter III

HOW THE SKI-OPTOMETER ASSISTS IN REFRACTION

THE construction of the Ski-optometer has now been fully explained, and the reader realizes that since the instrument contains all the lenses necessary in making an examination, greater operative facility is afforded through its use than where the trial-case lenses are employed.

The Ski-optometer is "an automatic trial-case" in the broadest sense of the term, wholly superseding the conventional trial-case. It should therefore be employed throughout an entire examination, wherever trial-case lenses were formerly used. To fully realize its labor saving value in obtaining accurate examination results, it is only necessary to recall the tedious method of individually handling and transferring each lens from the trial-case to the trial-frame, watching the stamped number on each lens handle, wiping each lens and in the case of cylindrical lenses setting each one at a designated axis—all being needless steps where the Ski-optometer is employed.

The Use of the Ski-optometer in Skioscopy

In skioscopy, the Ski-optometer offers the refractionist assistance of the most valuable character.

For example, assuming that extreme motion in the opposite direction with plane or concave mirror is obtained with a +1.25D. spherical lens before the patient's eye; by quickly turning the Ski-optometer's single reel until the two white zeros again appear, +2.50D is secured, as explained in the previous chapter. If this continues to give too much "against motion," the lens power should be quickly increased to +3.75 or +5.00D if necessary (Fig. 4). Should the latter reveal a shadow in the reversed direction, the refractionist is assured that it is the weakest lens that will cause its neutralization. Practically but few lenses have been used to obtain the final result proving the instrument's importance and time-saving value in skioscopy, and demonstrating the simplicity with which tedious transference of trial-case lenses is avoided.

Furthermore, it should be noted that where the Ski-optometer is used in skioscopy, it is not necessary to remove the retinoscope from the eye or to constantly locate a new reflex with each lens change. This permits a direct comparison of the final lens and eliminates the usual difficulty in mastering skioscopy. The chief cause of this difficulty is due to the fact

that the transferring of the trial-case lenses makes it practically impossible for the student to determine whether the previous lens caused more "with" or "against" motion.

Where the indirect method is employed in skioscopy, best results are secured through the use of the Woolf ophthalmic bracket and con-

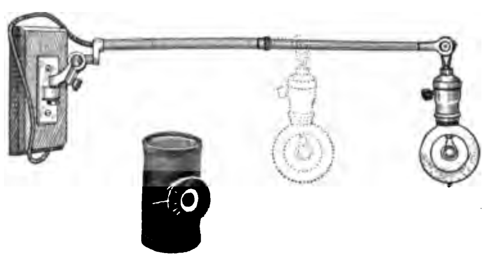


Fig. 9—The Woolf ophthalmic bracket. A convenient and portable accessory in skioscopy and muscle testing; can be used with or without Greek cross.

centrated filament lamp,together with an iris diaphragm chimney. The latter permits the reduction or increase of the amount of light entering the eye, as it is agreed that a large pupil requires *less* light, a small pupil requiring *more* light. The bracket referred to permits the operator to swing the light into any desired position (Fig. 9), while the iris diaphragm chimney serves as a shutter. This apparatus may also be employed for

muscle testing, as described in a subsequent paragraph.

A Simplified Skioscopic Method

In using the Ski-optometer, instead of working forty inches away from the patient in skioscopy and deducting 1.D., the refractionist will find it more convenient to work at a twenty-inch distance, deducting 2.D. This working distance may be accurately measured and maintained by using the reading rod accompanying the instrument. Instead of deducting 2.D. from the total findings, however, it is preferable to insert a +2.D. trial case lens in the rear cell of the instrument directly next to the patient's eye. After determining the weakest lens required to neutralize the shadow in both meridians, the additional +2.D. lens should be removed and the total result of the examination read from the instrument's register.

To illustrate a case in skioscopy where spherical lenses are employed to correct both meridians, assume that the vertical shadow requires a +1.25D lens to cause its reversal, while the horizontal requires +2.00D. Employment of the customary diagram, illustrated in Fig. 10, would show the patient required +1.25 sph. = +.75 cyl. axis 90, which

when transposed is equivalent to +2.00 Sph. = —.75 cyl. axis 180°.

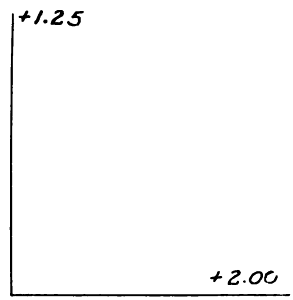


Fig. 10—Where spherical lenses are employed in Skioscopy, above indicates patient requires + 125 Sph. = + 75 Cyl. Axis 90° or + 2 Sph. = — 75 Cyl. Axis 180°

It should be noted that the total spherical power is +2.00D, as the Ski-optometer's register shows, while the difference between the two meridians is·75, which is the required strength of the cylinder. By then turning the cylinder reel to .75, and setting the axis indicator at 180° (because by using minus cylinders, the axis must be reversed) the patient should read the test type with ease if the skioscopic findings are correct. Thus with the Ski-optometer, it is not even necessary to learn transposition, since the instrument automatically accomplishes the work, avoiding all possibility of error.

EMPLOYING SPHERES AND CYLINDERS IN SKIOSCOPY

Another commonly used objective method may be employed with even greater facility through the combined use of both the Ski-optometer's spherical and cylindrical lenses. As previously suggested, insert the +2.00 spherical trial-case lens in the rear of the instrument, working at a twenty inch distance, then proceed to correct the strongest meridian first.

It was assumed that it required a +2.00 spherical to neutralize the strongest, or horizontal meridian, as shown in Fig. 10. The refractionist should then set the axis indicator therewith, which is the axis of the cylinder, or 180°.

It is then merely a matter of increasing the Ski-optometer's cylindrical lens power until the reversal of the shadow in the weakest meridian is determined. Assuming this proves to be —.75 cylinder, axis 180°, the patient's complete prescription +2.00 sph. = —.75 cyl. axis 180°, would be registered in the Ski-optometer without any further lens change other than the removal of the +2.00 working distance lens.

However, regardless of the method employed, the Ski-optometer greatly simplifies

skioscopy. In fact, the instrument was originally intended to simplify retinoscopy or skioscopy, as the subject should be termed, the name "Ski-optometer" having been derived from the latter.

USE OF THE SKI-OPTOMETER IN SUBJECTIVE TESTING

In subjective refraction, especially where the "better or worse" query must be decided by the patient, it is commonly understood that the refractionist is compelled to first increase and then decrease a quarter of a diopter before the final lens is decided. With the Ski-optometer, the usual three final changes are made in far less time than it takes to make even *one* lens change from trial-case to trial-frame.

For example:

Assuming, with a +1.25D spherical lens before the patient's right eye, he remarks that he "sees better" with a +1.D. while +.75D is not as satisfactory. The refractionist can then quickly return to +1.D., simply turning the Ski-optometer's single reel *outward* to increase, or *backward* to decrease, the lens strength. So rapidly have these lens changes been made, that the patient quickly sees the difference of even a *quarter* diopter, and quickly replies, "better" or "worse."

This is made possible because the eye does

not "accommodate" as quickly as the lens change made with the Ski-optometer. It should also be noted that the eye receives an image on its retina within one-sixteenth of a second; otherwise, the patient is forced to accommodate, making it difficult to see the difference of even a quarter dioptre. On the other hand, in transferring trial-case lenses, with its slow, tedious procedure, the patient, being unable to detect the slight difference of only a quarter diopter, unhesitatingly replies, "no difference," merely because they are compelled *to accommodate.*

A Simplified Subjective Method

The following simplified method of procedure is suggested for subjective testing with the Ski-optometer, although as previously explained, the refractionist may employ his customary method, overcoming the annoyance of transferring trial-case lenses and the setting of each cylinder individually. The Ski-optometer has been constructed and based upon the golden rule of refraction: "As much plus or as little minus spherical, combined with as little minus cylinder power as the patient accepts."

By applying this rule as in the above method and starting with +5.D. spherical, watching

the two zeros (Fig. 4) and rapidly reducing +1.25D each time, we will assume that +1.25D gives 20/30 vision; as a final result +1.D. will possibly give 20/25 vision.

The patient's attention should next be directed to the most visible line of type, preferably concentrating on the letter "E" or the clock dial chart—either of which will assist in determining any possible astigmatism. Since the Ski-optometer contains concave cylinders exclusively, the next move should be the setting of its axis indicator at 180°, commonly understood as "with the rule." One should then proceed to determine the cylinder lens-strength by turning the reel containing the cylindrical lenses (Fig. 8). Should the patient's vision fail to improve after the —.50D. cylinder axis 180° has been employed, the refractionist, in seeking an improvement, should then slowly move the axis indicator through its entire arc.

With the cylinder added, regardless of axis, poor vision might indicate the absence of astigmatism. If astigmatism exists, vision will usually show signs of improvement at some point, indicating the approximate axis. Once the latter is ascertained, the refractionist may readily turn the Ski-optometer's cylinder reel and obtain the correct cyl-

inder lens strength, after which the axis indicator should be moved in either direction in order to obtain the best possible vision for the patient.

The refractionist should always aim to obtain normal (or 20/20) vision with the weakest concave cylinder, combined with the strongest plus sphere, or weakest minus sphere.

Procedure for Using Minus Cylinders Exclusively

For the benefit of those who have never used minus cylinders exclusively in making their examinations, we will assume that the patient requires O.U. +1.D Sph. = —1D cyl. axis 180° for final correction; the latter, in its transposed form, being equivalent to +1.D. cylinder axis 90°. Unquestionably the best method is the one that requires the least number of lens changes to secure the final result.

To obtain this, the following order of lens change should be made: First, +1.D. sphere is finally determined and allowed to remain in place. Concave cylinders are then employed in quarters until the final results of +1.D. spherical, combined with —1.D. cylinder axis 180° is secured. This necessitates the change of but *four* cylindrical lenses as shown in routine "A" as follows:

ROUTINE "A" (Made with *minus* cylinder)				ROUTINE "B" (Made with *plus* cylinder)			
	Sph. +1.D.	Cyl.	Axis		Sph. +1.D.	Cyl.	Axis
Step 1	+1.D. =	—25	ax. 180°	equal to	+.75 =	+.25	ax. 90°
Step 2	+1.D. =	—50	ax. 180°	equal to	+.50 =	+.50	ax. 90°
Step 3	+1.D. =	—75	ax. 180°	equal to	+.25 =	+.75	ax. 90°
Step 4	+1.D. =	—1	ax. 180°	equal to	0	+1	ax. 90°.

In brief the method of using minus cylinders exclusively in an examination, as explained in routine "A", necessitates the change of the cylinder lenses only after the *strongest* plus sphere is secured.

On the other hand, notwithstanding innumerable other methods where plus cylinders are used, routine "B" shows that the best spherical lens strength the patient will accept, is also first determined. Then both spheres and cylinders are changed in their regular order by gradually building up in routine, by increasing plus cylinder and next decreasing sphere, a quarter dioptre each time, until the final result is secured.

While it is conceded that both routine "A" and "B" are of themselves simplified methods, by comparing routine "A" where minus cylinders are used with routine "B" where plus cylinders are used in their corresponding steps, the refractionist will note by comparison that one is the exact equivalent and transposition of the other. Where *plus* cylinders are

employed, eight lens changes are made before final results are secured; while but four lens changes are necessary where *minus* cylinders are used.

The refractionist should also note by comparison that the use of minus cylinders reduces focus of the plus sphere, but only in the meridian of the axis. It has not made the patient myopic. Furthermore, a plus cylinder will bring the focal rays forward, while minus cylinders throw them backward toward the retina.

This is but another reason for the exclusive use of minus cylinders in refraction.

The method of using *minus cylinders* exclusively in an examination, necessitates the change of the cylinder lenses *only*. On the other hand, the method of using plus cylinders makes it necessary to change spheres and cylinders in routine.

In brief, since using the minus cylinder is merely a matter of mathematical optics, their use even in a trial-case examination is strongly urged.

The maximum value of the Ski-optometer is fully realized only when the advantages of using minus cylinders exclusively in every examination is clearly understood.

CONSTANT ATTENTION NOT REQUIRED

With the Ski-optometer, when the examination is completed, the sum-total of final results—whether spherical, cylinder, axis, or all combined—are automatically indicated or registered ready to write the prescription. *Until then,* the foci of the various lenses that may be employed are of no importance.

In short, in using the Ski-optometer, it is not necessary to constantly watch the registrations during examinations. The automatic operation of the instrument is an exclusive feature, so that the refractionist should unhesitatingly employ it. Hence, by eliminating the perpetual watch on the lenses in use, the refractionist is enabled to give his undivided attention to the patient rather than to the trial lenses.

Where a special dark-room is used for skioscopic work, an additional wall bracket or floor-stand will necessitate only the removal of the instrument itself. This enables the refractionist to use the Ski-optometer for subjective or objective work, without disturbing the patient's correction.

Chapter IV

IMPORTANT POINTS IN CONNECTION WITH THE USE OF THE SKI-OPTOMETER

THE Ski-optometer is equipped with an adjustable head-rest, permitting its lenses to be brought as close as possible to the eye without touching the patients lashes, a matter of importance in every examination.

Fig. 11—The nasal lines of the Ski-optometer fit the contour of face with mask-like perfection, patient remaining in comfortable position.

Elimination of Trial Frame Discomfort

Where the Ski-optometer is correctly fitted to the face, the patient invariably remains in a comfortable position (Fig. 11). The instrument is shaped to fit the face like a mask,

so that even with a pupillary distance of but 50 m/m (that of a child). there still remains, without pinching, ample room for the widest nose of an adult.

Before making an examination, the correct pupillary distance should always be obtained by drawing an imaginary vertical line downward through the center of each eye from the 90° point on the Ski-optometer axis scale. The pupillary distance will then register in millimeters on the scale of measurements for each eye separately. If the Ski-optometer is correctly adjusted, the patient is securely held in position, the cumbersome trial-frame being entirely eliminated.

Rigidity of Construction

Illustration on following page (Fig. 11a) shows the reinforced double bearing arms which hold the Ski-optometer lens batteries at two points. This eliminates possibility of the instrument getting out of alignment, and prevents wabbling or loose working parts.

The broad horizontal slides shown in the cut, move in and out independently so that the pupillary distance is obtained for each eye separately by turning the pinioned handle on either side of the instrument. The scale denotes in millimeters the P.D. from the median

line of the nose outward, the total of both scales being the patient's pupillary distance.

Fig. 11a also serves to show the staunch construction of the base of the Ski-optometer.

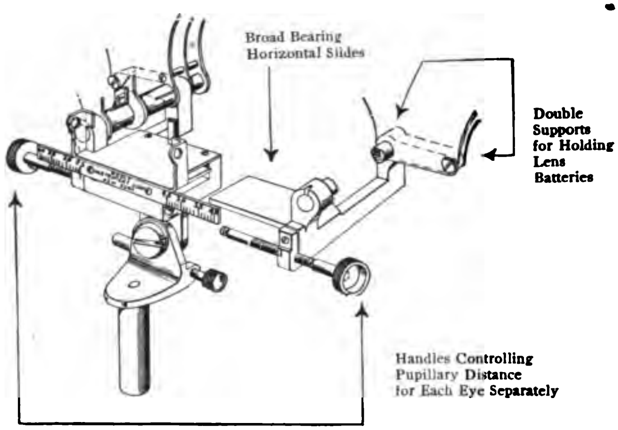


Fig. 11A—Showing staunch construction of Ski-optometer. base.

HOW TO PLACE THE SKI-OPTOMETER IN POSITION

The patient should be placed in a comfortable position with "chin up," as though looking at a distant object. The instrument should then be raised or lowered by the adjustable ratchet wheel of the bracket. The wall bracket gives best results when suspended from the wall, back of the patient, as shown on page 135. This bracket should be placed about ten inches above the head of the aver-

age patient. When the Ski-optometer is placed in position for use, its lower edge will barely touch the patient's cheeks. It is sometimes advisable to request the patient to lightly press toward the face the horizontal bar supporting the instrument. Particularly good results are secured where a chair with a head-rest is employed in conjunction with the Ski-optometer. (See illustration of Model Refraction Room, Page 112).

Cleaning the Lenses

The time-waste of perpetually cleaning lenses is overcome where the Ski-optometer is employed. For the convenience of the operator and protection of Ski-optometer lenses, the latter are concealed in a dust-proof cell, overcoming all dust and finger-print annoyances. When not in use, the instrument should be covered with the standardized hood forming part of the equipment.

The instrument should not be taken apart under any circumstances. To clean its lenses, not a single screw need be removed, as the lenses of each disk may be cleaned individually through the opening of the other disks. These openings are conveniently indicated by the white zeros (Fig. 2). The Ski-optometer contains but eleven spherical and eight cylin-

drical lenses on each side, so that the actual work of cleaning should not require over ten minutes at the most, cleaning the lenses every other week proving quite sufficient.

Accuracy Assured in Every Test

Loss of refraction is completely eliminated through the use of the Ski-optometer. The most casual examination of the trial-frame or any other instrument shows that the construction necessitates the placing of the spherical lens next to the eye with the cylinder lens outermost—a serious fault wholly overcome in the Ski-optometer.

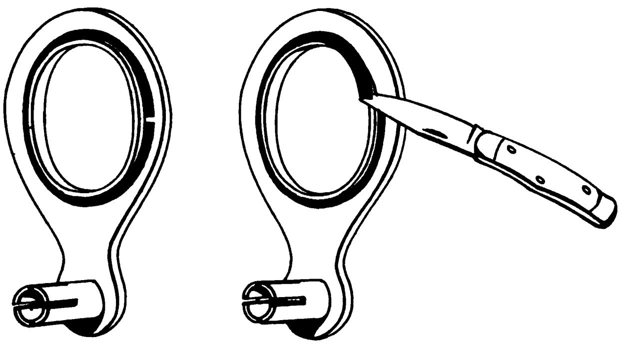
Not only do the cylindrical lenses of the Ski-optometer set directly next to the patient's eye, thus overcoming any possible loss of refraction, but the strong spherical lenses of the supplementary disk are set directly next to the cylinder. There is apparently but a hair's distance between these lenses; the two disks containing the spherical lenses of the Ski-optometer likewise setting close together.

In a word, the Ski-optometer's cylinder lenses set directly next to the patient's eye, followed by the stronger sphericals, so that the weakest spherical or +.25 (the lens of least importance) sets farthest away. This is 3½ m/m closer than any trial frame manufac-

tured, however, and at least 10 m/m closer than any other instrument—another reason for implicitly relying on the Ski-optometer for uniformly accurate results.

Built to Last a Lifetime

The Ski-optometer is built on the plan of 1/1000″, insuring absolute rigidity and accu-



A B

Fig. 12—(A. and B.)—This unique, patented split-spring device of screwless construction, securely holds all movable parts. In case of repair, they may be removed with the blade of a knife.

racy and a lifetime of endurance. Particular and detailed attention has been given to the novel means of eliminating screws which either bind, create friction or continually work loose, causing false indications of findings on scales of measurements; hence correct and accurate indications are insured in the

Ski-optometer by means of a split spring-washer construction similar to that of an automobile tire's detachable rim (Fig. 12).

This patented spring-washer construction securely holds the phorometer lenses, the rotary prism and the revolving cylinder lens cells.

Whenever necessary, or in case of repair, these parts may be readily removed with the blade of a knife.

Chapter V

CONDENSED PROCEDURE FOR MAKING SPHERE AND CYLINDER TEST WITH THE SKI-OPTOMETER

NOTWITHSTANDING various methods employed, for both subjective and objective refraction, the following synopsis of the previous chapters will unquestionably prove most valuable to the busy refractionist, enabling him to make error-proof examinations in practically every case without resorting to the transference of trial case sphere or cylinder lenses. A careful reading of chapters one and two should be made however, so that one may gain an understanding as to how spheres and cylinders are obtained with the Ski-optometer.

Subjective Distance Test

1st—Place Ski-optometer in position, employing spirit level, thus maintaining instrument's horizontal balance.

2nd—Adjust the pupillary distance for each eye individually, by drawing an imaginary vertical line downward through the center of each eye from the 90° point on the Ski-optometer's axis scale. The opaque disk should be placed before the patient's left eye by setting the supplementary disk handle at "shut."

3rd—The Ski-optometer lens battery before the patient's right eye should be set at "open" (figure 2), whereupon the first turn of spherical lens battery toward the nasal side places a +6.D sphere in position. This should blur vision of average patient.

4th—It is now only necessary to remember that an outward turn toward temporal side of the instrument increases plus sphere power, while a nasal turn decreases it. Therefore continue to reduce convex spherical lens power until the large letter "E" on the distant test card is clear. Then request patient to read as far down as possible,—a rapid turn of a quarter dioptre being readily accomplished with the Ski-optometer (Fig. 4).

5th—In the event of working down to "zero" with spheres, the supplementary disk handle or indicator should next be set at —6.D sphere, while the spherical reel should be turned toward the nasal side—thus building up on minus spheres (Fig. 6). In short, the strongest plus sphere or weakest minus sphere should always be determined before employing cylinders.

6th—With the best spherical lens that the patient will accept left in place, direct attention to the letter E or F in the lowest line of type the patient can see on the distant test

letter chart. Then set axis indicator at 180° (Fig. 7).

7th—Next increase concave cylinder power until vision is improved. If vision is not improved after increasing cylinder strength to —.50 axis 180°, merely reverse the axis to 90°. If vision is improved, cylinder lens strength should be increased. If not, it should be decreased (Fig. 8).

8th—Slowly move axis indicator through entire arc of axis, thus locating best possible axis (Fig. 7).

9th—After sphere and cylinder test of right eye has been made, place supplementary disk handle at "shut." Then repeat procedure in testing left eye.

10th—After completing examination for each eye separately, then, with both of the patient's eyes open, direct attention to lowest line of type he can see, concentrating on the E or F, simultaneously increasing or decreasing spherical power before both eyes. The refractionist merely recalls that by turning the Ski-optometer's single reel toward the temporal side, convex spherical power is increased, by turning toward the nasal side for either eye, spherical power is decreased. Cylinder lens strength may be changed in a like manner before both eyes simultaneously.

11th—After making the distance test, then only is it necessary to copy the result of the examination as recorded by the Ski-optometer.

Subjective Reading Test

Tilt Ski-optometer forward in making reading test. The wide groove in the horizontal bar supporting the instrument, permits it to be slightly tilted.

12th—Place Ski-optometer reading rod in position with card at about 14 inches. Close off one eye. Direct patient's attention to the name "Benjamin" printed at top of card.

13th—Leave cylinder lens in place. Proceed as in distance test with +6.D sphere, fogging down until the first word "laugh" on the reading card, in line 75M, is perfectly clear, this being slightly smaller than the average newspaper type.

14th—After completion of examination for each eye separately, then with both eyes direct patient's attention to word "laugh." Move reading card in or out a few inches either side of 14 inch mark. This will determine any possibility of an over-correction. Then record prescription just as Ski-optometer indicates. For a detailed description of above, as well as for objective testing with the Ski-optometer, read chapter three.

Chapter VI

MUSCULAR IMBALANCE

THE purpose of the present chapter is to acquaint the refractionist with the operation of the Ski-optometer as "a scientific instrument for muscle testing"—the subject being treated as briefly and comprehensively as is practicable.

As the reader progresses in the subject of muscular anomalies, he may carry his work to as high a plane as desired, increasing his professional usefulness to an enviable degree.

Through the use of the Ski-optometer, muscle testing may be accurately accomplished in less time than a description of the operation requires. Furthermore, tedious examinations may be wholly overcome through the discontinuance of the consecutive transference of the various degrees of prisms from the trial case. In fact, the latter method has long been quite obsolete, owing to the possibility of inaccuracy. The muscle action of the eye is usually quicker than the result sought through the use of trial-case prisms; hence muscle testing with the Ski-optometer is accomplished with far greater rapidity and accuracy, thus making the instrument an invaluable appliance in every examination.

The Action of Prisms

Students in refraction—and one may still be a student after years of refracting—are sometimes puzzled as to just what a prism does when placed before an eye. They refer to every available volume and are often confused between ductions and phorias, finally dropping the subject as an unsolvable problem. In view of this fact, it is suggested that the refractionist should read the present volume with the actual instrument before him.

Before proceeding, one should first understand the effect of a prism and what it accomplishes. To determine this, close one eye, looking at some small, fixed object; at the same time, hold a ten-degree prism base-in before the open eye, noting displacement of the object. This will clearly show that the eye behind the prism turns toward the prism apex.

To carry the experiment further, the following test may be employed on a patient. Covering one eye, direct his attention to a fixed object, placing the ten degree prism before the eye, but far enough away to see the patient's eye behind it. As the prism is brought in to the line of vision, it will be seen that the eye turns towards the apex of the

prism. When the prism is removed, the eye returns to its normal position.

Similar experiments enable the refractionist to make the most practical use of treating phorias and ductions, as well as to comprehend all other technical work.

Fig. 13—An important part of the equipment for muscular work.

The Phorometer

As previously stated, it is practically impossible to accurately diagnose a case of muscular imbalance with trial case prisms. For this reason the phorometer forms an important part of the equipment for muscle testing in the Ski-optometer, having proven both rapid and

accurate. It consists of two five-degree prisms with bases opposite, each reflecting an object toward the apex or thin edge. The patient whose attention is directed to the usual muscle-testing spot of light, will see *two* spots.

Aside from the instrument itself, and in further explanation of the phorometer's principle and construction, when two five-degree prisms are placed together so that their bases are directly opposite, they naturally neutralize; when their bases are together, their strength is doubled. Thus while the prisms of the phorometer are rotating, they give prism values from plano to ten degrees, the same being indicated by the pointer on the phorometer's scale of measurments.

As a guide in dark-room testing, it should be noted that the handle of the phorometer in a vertical position is an indication that the vertical muscles are being tested; if horizontal, the horizontal muscles are undergoing the test.

The Maddox Rod

The Maddox rod (Fig. 14) consists of a number of red or white rods, which cause a corresponding colored streak to be seen by the patient. This rod is placed most conveniently on the instrument, being pro-

vided with independent stops for accurately setting the rods at 90 or 180 degree positions.

Fig. 14—The Maddox Rod, a valuable aid in making muscular tests.

The Maddox rod has proven of valuable assistance in detecting muscular defects, particularly when used in conjunction with the phorometer. Thus employed, it enables the patient to determine when the streak seen with one eye crosses through the muscle-testing spot-light observable by the other eye, as hereafter described.

Procedure for Making the Muscle Test

The Ski-optometer should be equipped with *two* Maddox rods, one red and one white. Their combined use is of the utmost importance since they assist in accurately determining cyclophoria and its degree of tortion as

designated on the degree scale, and fully described in a later chapter.

When the Maddox rods are placed in a vertical position, it is an indication that the vertical muscles are being tested; when placed horizontally, the horizontal muscles are being tested. It should be particularly noted that the streaks of light observable through the Maddox rods always appear at right angles to the position in which they lie.

The Ski-optometer should be placed in a comfortable position before the patient's face with the brow-rest and pupillary distance adjusted to their respective requirements. The instrument should be levelled so that the bubble of the spirit level lies evenly between its two lines, thus insuring horizontal balance. The muscle-test light should be employed at an approximate distance of twenty feet on a plane with the patient's head. Best results in muscle testing are secured through the use of the Woolf ophthalmic bracket, with iris diaphragm chimney and a specially adapted concentrated filament electric lamp (Fig. 9). This gives a brilliant illumination which is particularly essential. The test for error of refraction should be made in the usual manner, using the spherical and cylindrical lenses contained in the Ski-optometer,

thus obviating the transference of trial-case lenses and the use of a cumbersome trial frame. The time-saving thus effected enables the refractionist to include a muscle test in every examination and without tiring the patient—a consideration of the utmost importance.

Binocular and Monocular Test

The test for muscular imbalance may be divided in two parts. First, binocular test, or combined muscle test of the two eyes; second, monocular test, or muscle test of each eye separately. The latter does not signify the shutting out of vision or closing off of either eye, since muscular imbalance can only be determined when both eyes are open. These two tests are fully explained in the following chapter.

Chapter VII

THE BINOCULAR MUSCLE TEST

Made with the Maddox Rod and Phorometer

DIRECTING the patient's attention to the usual muscle testing spot of light, the *red* Maddox rod should be placed in operative position before the eye, with the single *white* line or indicator on red zero (Fig. 15). The rods now lie in a vertical position.

Fig. 15—The Maddox rods placed vertically denote test for right or left hyperphoria, causing a horizontal streak to be seen by patient.

The pointer of the phorometer should likewise be set on the neutral line of the red scale, causing the handle to point upward (Fig. 16). A distance point of light and a red streak laying in a horizontal position should now be seen by the patient.

Fig. 16—The phorometer handle placed vertically, denotes vertical muscles are undergoing test for right or left hypherphoria—as indicated by "R. H." or "L. H."

Instead of memorizing a vast number of rules essential where trial case prisms are employed for testing ocular muscles, the pointer of the phorometer indicates not only the degree on the red scale, but the presence of right hyperphoria (R. H.) or left hyperphoria, (L. H.).

Fig. 17—The horizontal streak caused by Maddox rod bisecting muscle testing spotlight for vertical imbalance, as patient should see it.

Assuming that the patient finds that the streak *cuts through* the point of light, the re-

Fig. 18—The Maddox rods placed horizontally test esophoria or exophoria, causing a vertical streak to be seen by the patient.

fractionist instantly notes the absence of hyperphoria. Should the point of light and the red streak *not* bisect, prism power must be added by rotating the phorometer's handle to a position that will cause the streak to cut through the light (Fig. 17). While testing for hyperphoria, the red scale should alone be employed, the white scale being totally ignored.

Esophoria and Exophoria

The next step is to set the white lines of the red Maddox rod either at white zero, or 180° line, with the rods in a horizontal position (Fig. 18) and the phorometer on the white neutral line, with handle horizontal, (Fig. 19), thus making the test for esophoria or

exophoria, technically known as lateral deviations.

The red streak will now be seen in a vertical position. Should it bisect the spot of light, it would show that no lateral imbalance exists. Should it not bisect, the existence of either esophoria or exophoria is proven, necessitating the turning of the phorometer handle. Should the refractionist rotate the handle in a direction opposing that of the existing imbalance, the light will be taken further away from the streak, indicating that the rotation of the prisms should be reversed.

At the point of bisection (Fig. 20), the phorometer will indicate on the white scale

Fig. 19—The phorometer handle placed horizontally denotes horizontal muscles are undergoing test for esophoria or exophoria indicated by "Es." or "Ex."

whether the case is esophoria or exophoria and to what amount. In testing esophoria (ES) or exophoria (EX), the white scale is alone employed, no attention being given to the red scale.

Fig. 20—The vertical streak bisecting muscle testing spotlight for horizontal imbalance, as patient should see it.

Making Muscle Test Before and After Optical Correction

It is considered best to make the binocular test *before* regular refraction is made, making note of the findings; and again repeating the test after the full optical correction has been placed before the patient's eye. This enables the refractionist to definitely determine whether the correction has benefited or aggravated the muscles. Furthermore, by making the muscle test before and after the optical correction, a starting point in an examination is frequently attained. For ex-

ample, where the phorometer indicates esophoria it is usually associated with hyperopia, whereas exophoria is usually associated with myopia, thus serving as a clue for the optical correction.

Assuming for example that the binocular muscle test shows six degrees of esophoria without the optical correction, and with it but four degrees, it is readily seen that the imbalance has been benefited by the optical correction. Under such conditions it is safe to believe that the optical correction will continue to benefit as the patient advances in years, tending to overcome muscular defect.

When to Consider Correction of Muscular Imbalance

In correcting an imbalance, it is also a good plan to adhere to the following rule: In case of hyperphoria, either right or left, consider for further correction only those cases that show one degree or more. In exophoria, those showing three degrees or more. In esophoria, correct those showing five degrees or more, except in children, where correction should be made in cases showing an excess of 3° of esophoria. These rules are naturally subject to variation according to the patient's

refraction and age, but they are generally accepted as safe.

Four Methods for Correction of Muscular Imbalance

There are four distinct methods for correcting muscular imbalance, each of which should be carried out in the following routine:

1. *Optical correction* made with spheres or cylinders, or a combination of both.

2. *Muscular exercising* or "ocular gymnastics." This is accomplished on the same principle as the employment of other forms of exercises, or calisthenics.

3. *The use of Prisms*: When the second method fails, prisms are supplied, with base of prism before the weak muscle, for rest only.

4. *Operation*: If the above three methods, as outlined in the following chapters, have been carefully investigated, nothing remains but a tetonomy or advancement, or other operative means for relief and satisfaction to the patient.

The Rotary Prism

The rotary prism of the Ski-optometer, (Fig. 21) consists of a prism unit, having a total equivalent of thirty degrees. It is composed of two fifteen-degree prisms, back to

back, so that the turn of its pinion or handle causes each of its lenses to revolve, one on the other. When its bases are opposite, they neutralize; when directly together, they give a total value of thirty degrees. While revolving from zero to maximum strength, they give prism values which are indicated on the scale of measurements, the red line denoting the total prism equivalent.

Fig. 21—Turning rotary prism's pinioned handle gives prism value from zero to 30° as indicated by prism's red line indicator.

It is obviously essential to know where the base of the rotary prism is located. Therefore if prism in or out is desired, the zero graduations should be placed vertically and the red line or indicator set at the upper zero (Fig. 21).

A rotation inward to 10 would give a prism

equivalent of ten degrees, base *in*. A rotation from zero to 10 outward would give a prism equivalent of ten degrees, base *out*, etc. With zero graduations horizontal and the red line or indicator set therewith, a rotation upward to ten on the scale would give a prism equivalent of ten degrees, base *up*. A rotation from zero downward to 10 would give a prism equivalent of ten degrees, base *down*.

An understanding of the foregoing will show that a rotation of the red line, or indicator, will give prism value from zero to 30, with base up, down, in or out.

Use of the Rotary Prism in Binocular Muscle Tests

Should a case be one of esophoria, exceeding the ten degree range of the phorometer, the rotary prism should be brought into operative position with cypher (0) graduations vertical (Fig. 21), while the red line or indicator should be set at 10 on the outer or temporal scale. The phorometer's indicator should again be set on the center or neutral line on the white scale. The rotary prism will then add ten degrees to the esophoria reading indicated on the phorometer.

Should the case be one of exophoria, exceeding ten degrees, the indicator should be set

at ten degrees upon the inner or nasal scale and the indicator of the phorometer should then be set at the white center or neutral line, as in the previous test. Should prism power ever be required to supplement the phorometer in hyperphoria, the rotary prism should be employed with zero graduations horizontal, and the red line or indicator set at ten degrees on upper or lower scale, as required.

Chapter VIII

THE MONOCULAR DUCTION MUSCLE TEST

Made with Both Rotary Prisms

WHILE the previously described binocular muscle test made with the phorometer and Maddox rod, only determines the existence and amount of esophoria, exophoria, and hyperphoria, neither the faulty nor the deviating muscle is located, hence a *monocular muscle test* is essential in order to determine whether the muscles of the right or left eye are faulty. Furthermore, an imbalance may possibly be due to either a faulty muscular poise, or lack of nerve force in one or both eyes. A "duction test" should accordingly be made of each muscle of each eye separately, followed by a comparison of the muscular pull of both eyes collectively.

These tests are commonly termed adduction, abduction, superduction and subduction, and are defined in the order named. They include tests of the vertical and horizontal muscles of each eye, made individually by means of the rotary prisms, each being placed before the eye undergoing the test.

Locating the Faulty Muscle

The phorometer and the Maddox rod

should be removed from operative position, discontinuing the use of the muscle-testing spot-light, employed in the previously described binocular test. The optical correction, if one is required, should be left in place, while the patient's attention should be directed, with both eyes open, to the largest letter on the distant test chart; or if preferable, the Greek cross in the Woolf opthalmic chimney may be used. Either one, however, should be located on a plane with the patient's head. As a guide for the operator, it might be well to remember that when the handle of the rotary prism is in a horizontal position, the lateral or horizontal muscles are being tested. On the other hand, when the handle is in a vertical position, the vertical muscles are undergoing the test.

Adduction

Adduction, or relative convergence, is the power of the internal muscles to turn the eyes inward; prism power base out and apex in, is employed.

To test adduction of the patient's right eye, the rotary prism should be placed in position before the right eye, the red line or prism indicator being registered at zero upon the prism upper scale. The two cyphers (0) should be placed in a vertical position with

Fig. 22—To test adduction, base out is required. Rotary prism's line or indicator should be rotated from zero outwardly. To test abduction, base in is required. Indicator should be rotated inwardly from zero.

the handle pointed horizontally (Fig. 21). The rotary prism should then be rotated so that its red line or indicator is rotated outward from zero until the large letter—preferably the largest letter, which is usually "E" —on the distance test-type or the Greek cross previously referred to, first appears to double in the horizontal plane. The reading on the scale of measurements should accordingly be noted. This test should be repeated several times, constantly striving for the highest prism power that the patient will accept without producing diplopia. The prism equivalent thus obtained will indicate

the right adduction and should be so recorded, as designated in Fig. 24. The amount of adduction ranges from 6 to 28, prism dioptres, the normal average being 24.

Abduction

Abduction is the relative power of the external muscles to turn the eyes outward. Prism power base in and apex out is employed. To determine abduction, or the amount of divergence of the external rectus muscle of the right eye, prism power with base in or toward the nasal side should be employed. The rotary prism will therefore remain in the same relative position as in making the adduction test (Fig. 22), with the two cyphers (0) or zero graduations vertical, but the indicator or red line should be rotated *inward* from zero, or towards the patient's nose.

With the patient's attention again directed to the large letter "E," or the Greek cross, this inward rotation should be continued until diplopia or double vision occurs. Like the former, this test should be repeated several times, the refractionist continuing to strive for the highest prism power which the eye will accept. This will indicate abduction of the right eye and should be so recorded as designated in

Fig. 24. The amount of abduction ranges from 3 to 10 prism dioptres. The normal average is 8.

The ratio of adduction to abduction is normally rated at about three to one. In other words, it is conceded that the power of the eye to converge is normally three times as great as its power to diverge, the usual measurements being eight to twenty-four respectively. While applicable in most instances, this may vary in different cases.

Superduction

Superduction, sometimes termed sursumduction, is the relative power of the superior recti to turn the eyes upward. Prism power base down and apex up is employed. To test superduction, the rotary prism should be placed in position with the two cyphers lying horizontally, with the handle pointed vertically (Fig. 23). The patient's attention should again be directed to the large letter "E", and the indicator or red line should be rotated downward from zero. The highest prism power that the patient will accept before the object appears to double in the vertical plane will indicate the degree of right superduction. This should be recorded accordingly. Conditions of this kind do not

usually exceed two or three degrees. The test, however, should be repeated several times before the final result is recorded, as indicated in Fig. 24. The amount of superduction ranges from 1 to 4 prism dioptres. The normal average is 2.

Fig. 23—To test superduction, base down is required. Rotary prism's line or indicator should be rotated downward from zero. To test subduction, base up is required. Indicator should be rotated upward from zero.

SUBDUCTION

Subduction, sometimes termed infraduction or deorsumduction, is the relative power of the inferior recti to turn the eyes downward. Prism power base up and apex down is employed. To test subduction, the rotary prism should be operated with zero graduations

placed horizontally, as in the superduction test (Fig. 23), but the indicator should be slowly rotated in the reverse direction, or upward from zero. With the patient's attention again directed to the large letter "E," or the Greek cross, the strongest degree prism thus secured without diplopia will indicate the right subduction. The amount of subduction ranges from 1 to 4 prism dioptres. The normal average is 2.

Any difference between superduction and subduction, usually denoting the existence of hyperphoria, should be given careful consideration.

Procedure for Monocular Muscle Testing

As previously explained, after a duction test of each of the four muscles of the right eye, the rotary prism before that eye should be placed out of position and the procedure for adduction, abduction, superduction and subduction repeated by means of the rotary prism before the left eye. In case of an existing imbalance, after testing the muscle of both right and left eyes, the refractionist can quickly determine which muscle or muscles may be lacking in strength (Fig. 24). In practically every instance muscle exercises or correcting prisms may then be prescribed

with definite knowledge of requirements, as further described in the following paragraphs.

A binocular muscle test made with the phorometer, Maddox rod and distant muscle - testing point of light might quickly indicate six degrees of exophoria, both before and after the optical correction is made. While this would doubtless be the correct amount of the manifest imbalance, it would be a difficult matter to ascertain which muscles caused the disturbance. To determine this important question, the monocular or duction test should be invariably employed.

Diagnosing a Specific Muscle Case

Assuming, for example, a specific case where six degrees of exophoria was determined in the binocular test that the muscle findings in the duction test show right adduction of twenty-four degrees, with an accompanying abduction of eight degrees; likewise a superduction and subduction of two degrees for each eye. With the aid of a chart or diagram—which should be made in every case—a comparison of these figures would indicate an exophoria of approximately six degrees, with a corresponding weak left internus (Fig. 24). This not only shows

the muscle pull of each eye individually, but a comparison of the two eyes as indicated by the dotted lines. Thus the relationship of the two eyes, and their corresponding muscles is quickly indicated.

DUCTION CHART

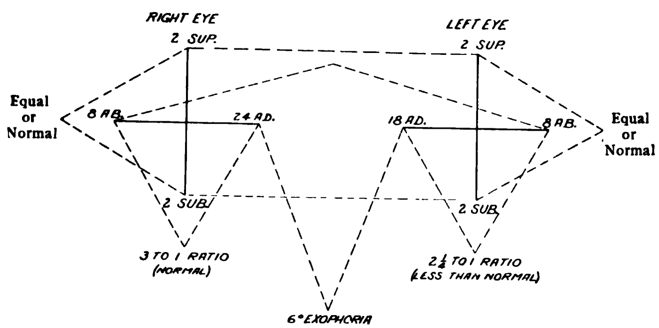


Fig. 24—Duction chart should be made in every case. Above readily shows existence of muscular imbalance and proves subduction and superduction for both eyes are equal; otherwise hypherphoria would be disclosed. Also note abduction for both right and left eye are equal, otherwise esophoria would be disclosed. Also note adduction for right eye is 24° while left is but 18°, proving a case of 6° of exophoria with a left weak internus.

A glance at the above diagram discloses the following three important facts, all of which should be known to the refractionist before a single thought can be devoted to the correcting of the case:

1. 6° exophoria is the amount of the insufficiency.
2. 18° adduction (which should be 24°).
3. Left weak internus.

As previously stated, the power to converge is normally rated 3 to 1, or 8 to 24, as shown above, while the power of the eye to look upward, is equal to the power to look downward. The diagram accordingly proves that the muscles of the right eye are in perfect balance, having equal muscular energy.

A comparison of the left eye shows adduction of 18 degrees with an abduction of 8 degrees, proving a lateral insufficiency because the ratio is less than 3 to 1; and the muscles of the left eye are at fault. The power of 2 degrees superduction and 2 degrees subduction, proves that no weakness exists in the vertical muscles.

After making the duction test for each eye individually, a comparison of both eyes in relationship to each other may be more readily determined by following the dotted lines (Fig. 24).

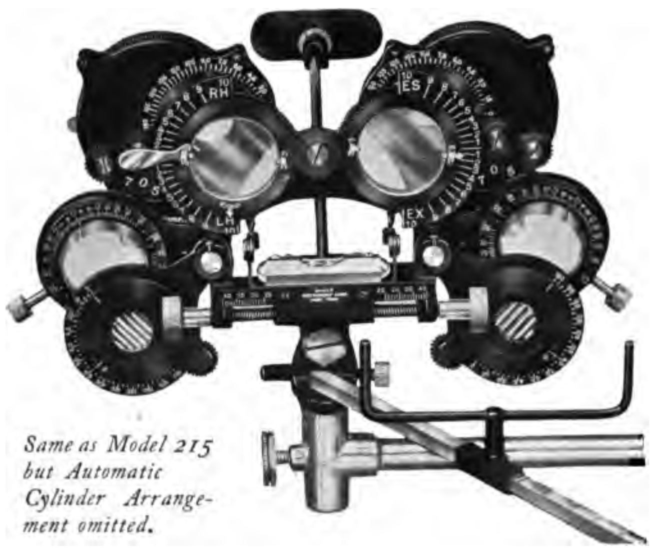
As previously stated, it is the inability of the two eyes to work together that causes the imbalance, so that if both eyes were normal, the adduction, abduction, superduction and subduction of the two eyes would agree.

The duction chart (Fig. 24.) also shows that the corresponding muscles of each eye agree—with the exception of the adduction

of the right eye and the left eye. This proves that the left internus is weak, measuring only 18 degrees instead of 24 degrees; it further proves the 6 degrees of exophoria in the monocular test, as was quickly and more readily determined in the binocular test.

Likewise, in cases of esophoria, hyperphoria, or cataphoria, the making of definite muscle measurements independently through the prescribed method would show through the merest glance at a similar diagram which muscle or muscles were relatively out of balance. Heterphoria of almost any type, or tendencies other than normal, may be fully investigated by making a thorough and separate test of each muscle.

Where an imbalance exists, a rapid test may be employed to distinguish a pseudo or false condition from a true condition. This is accomplished by first placing the two Maddox rods (both the red and white) so that the rods lie in a vertical position. If the two lines fuse, we have determined the existence of a false condition caused by a possible error of refraction or nerve strain. If the lines separate, we have determined a true muscular condition, and then only should the second method of muscular treatment follow.



Ski-optometer Model 205

Embodying Spherical Lenses Combined with Appliances for Testing and Correcting Muscular Imbalance.

Chapter IX

FIRST METHOD OF TREATMENT — OPTICAL CORRECTION

THE mere determination of the degree of an imbalance, or even the diagnosis of a patient's trouble, is not sufficient. If relief is to be secured, something more must be accomplished.

As previously stated, muscular imbalance may be corrected through one of the four following rules or methods, each explained in their relative order:

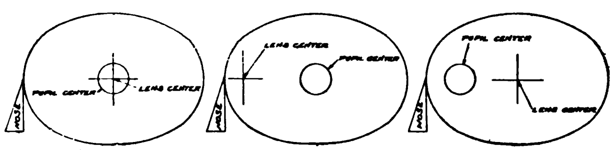
1—Optical Correction
2—Muscular Exercise
3—Use of Prism Lenses
4—Operative Methods

Esophoria

To correct a case of muscular imbalance, where six degrees of esophoria has been determined, the first rule of making the test for optical correction with the Ski-optometer's spherical and cylindrical lenses, would be in the line of routine. The binocular test made with the phorometer and combined use of the red Maddox rod would have determined the six degrees of esophoria.

The reason for making the binocular muscle test before and after the optical correction is because an imbalance is often aggravated or benefited by the correcting lenses. The optical correction frequently eliminates the need for further muscular treatment.

For example, we will assume that the optical correction tends to decrease the degree of esophoria from six degrees to four degrees. According to the previously mentioned rule for correcting cases exceeding one degree in hyperphoria, three degrees in exophoria and five degrees in esophoria, the condition would indicate that of being "left alone." Just what is taking place should be fully understood—its cause as well as its effect.



A — *Perfectly centered lens and pupil*
B — *Centered pupil and decentered lens*
C — *Centered lens and decentered pupil*

Fig. 25—Comparative diagram showing how a decentered lens before a centered eye has the same effect as a centered lens before a decentered eye.

When not otherwise specified, accurately centered lenses are of primary importance. The pupil of the eye should be directly behind the center of each lens (Fig. 25).

Figure "A" of the latter sketch illustrates a perfectly centered lens—its center indicated by a cross, the circle representing an eye directly behind it. Figure "B" illustrates a perfectly centered pupil behind a prism, with its center designated by a cross. To ascertain how the centered spherical lens takes the place of a prism, Figure "C" should be compared with Figure "B"; this will show that the eye is decentered, while the lens is centered. A further comparison will prove that the results in Figures "B" and "C" are identical, the correcting lenses having practically the same effect through the decentration of the eye as if a prism were prescribed, nature supplying its own decentration.

Treatment for Correcting Esophoria in Children

In case of esophoria, regardless of amount, slightly increased spherical power is frequently prescribed for children. This will naturally blur or fog the patient's vision, but in their effort to overcome the blur, accommodation is relaxed, usually tending to correct the muscular defect.

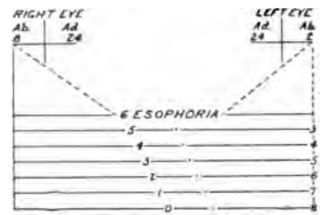
In such cases, as a rule, a quarter diopter increased spherical strength may frequently be added for each degree of esophoria as de-

termined before the optical correction was made. In a case of 6 degrees of esophoria, the refractionist may prescribe +1.50 dioptre spherical added to the optical correction, which, let us assume, is +1.00 sph. = —1.00 cyl. ax. 180°, so that the treatment glasses would be +2.50 sph. = —1.00 ax. 180° (See Procedure on Page 74).

At the end of each three months' period, the patient should be requested to return, when the binocular and the duction test should again be made, comparing results with the work previously accomplished. An improvement tending to build up the left weak externus will possibly permit of a decrease of the excessive spherical power, so that excessive spherical power is reduced until completely removed, in all probability overcoming the muscular defect. Esophoria is almost invariably a false condition and frequently is outgrown under this treatment as the child advances in years. On the other hand, esophoria uncared for in the child may tend to produce exophoria in the adult.

How Optical Correction Tends to Decrease 6° Esophoria in a Child

Assume binocular muscle test made before optical correction shows .... **6° Esophoria.**
+1. Sph. = — 1. Cyl. Ax. 180.



Next, locate faulty muscle by making a duction test, which shows how abduction of left eye is made to equal that of right eye, change being made quarterly with treatment lenses in accordance with following rule. Note as abduction is increased, esophoria is reduced.

Rule—prescribe a quarter dioptre increased sphere for each degree of imbalance or 0.25 x 6 equals: .... **+1.50 added to optical correction.**

1/1/19 (assumed date) prescribed treatment lenses equal: .... +2.50 = —1. × 180°.

4/1/19 (3 months later) assuming abduction has increased from 2° to 3° showing difference of 5 Es. or 0.25 x 5, equals +1.25 added to optical correction, prescribed treatment lenses equal: .... +2.25 = —1. × 180.

7/1/19 (3 months later) assuming abduction has increased from 3° to 4° showing difference of 4° Es. or 0.25 x 4 equals +1.00 which added to optical correction would make prescribed treatment lenses equal: .... +2.00 = —1. × 180.

And so on, every three months treatment lenses are prescribed until both right and left eye show 8° of abduction. In this way the treatment lenses are reduced to original correction of +1.00 = —100 x 180. This would have required six changes of lenses, three months apart—thus consuming 18 months time.

Chapter X

SECOND METHOD OF TREATMENT—MUSCULAR EXERCISE

Made With Two Rotary Prisms and Red Maddox Rod

Exophoria

IF a case is one of exophoria of six degrees, where the second method of treatment or muscular exercise is in line of routine, it is essential to first determine through a duction test and the preparation of the diagram exactly which one of the four muscles are faulty (Fig. 24).

Having determined, with the aid of the diagram, first, the existence of 6 degrees of exophoria; second, 18 degrees of adduction; third, a weak left internus—the next procedure is to determine what degree of prism will enable the patient to obtain single binocular vision, with both eyes looking "straight."

To determine this, place both of the Skioptometer's rotary prisms in position with the handle of each pointing outward horizontally. The red line or indicator of each prism should then be placed at 30° of the outer scale (Fig. 26).

The red Maddox rod should be horizontally

positioned before the eye, the white line on indicator pointing to 180° of the scale (Fig. 27). The strength of the rotary prism before the right eye should thereupon be reduced by rotating the prism indicator or red line toward the upper zero (0) to a point where the patient first sees the red streak—assuming that the red line appears at 42 degrees, that is 30 degrees before the left eye and 12 degrees before the right.

A B

Fig. 26 (A and B)—First position of rotary prisms to determine amount of prism exercise to be employed for building up the weak muscle.

The prism should then be still further reduced until the vertical streak produced by the Maddox rod directly bisects the muscle testing spot of light. Assuming that this point

be thirty-eight degrees, which is four degrees less, *single binocular vision is produced.*

Fig. 27—Position of red Maddox rod used in conjunction with Fig. 26 for prism exercising.

For example, sixty degrees of prism power (the combined power of the two rotary prisms) will usually cause complete distortion. Therefore, as outlined in Figure 28, the patient, seeing only out of the *right* eye, will detect nothing but a white light. By gradually reducing the strength of the prism before the right, which is the good eye, the patient will eventually see a red streak off to the left. A continued and gradual reduction to a point where the red streak bisects the white light, will determine how much prism power is required for the patient to obtain single binocular vision, thus establishing the

same image at the same time on each fovea or retina (Fig. 20).

This has taught the patient to do that which he has never before accomplished. Therefore, after having been taught how to make the two eyes work in relation to each other, the natural tendency thereafter will be to strive for the same relationship of vision with both eyes. The refractionist should then aim to reduce the excessive amount of prism required to give binocular vision, which can be accomplished by muscular exercise.

It must always be remembered before the refractionist is ready to employ the muscular exercise or second method, that the degree of prism required to give the patient single binocular vision must be determined with the optical correction in place. The exercise must be practised daily in routine, a daily record being essential.

An Assumed Case

We will assume a case where 42 degrees is required to enable the patient to first see the red streak as produced by the Maddox rod to the extreme left. Through a continued gradual reduction of 4 degrees (or to 38 degrees), we next learn that the streak was carried over until it bisected the white spot of light, giving

single binocular vision and producing a position of rest.

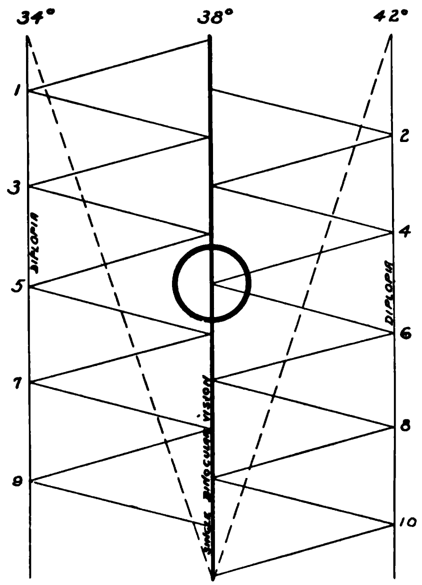


Fig. 28—Simplified chart showing the prism action employed in developing a weak ocular muscle through alternating prism exercise. Either side of 38° in excess of 4° causing diplopia.

The patient has now established the limitation of the exercise, which is four degrees, this limitation being determined by the difference between the point where the streak was first seen to the extreme side and where it bisected the spot. The same amount of four degrees should then be used for the opposite

side, thus reducing the prism strength to 34 degrees.

This again produces diplopia, because of the lesser amount of prism power employed to give single binocular vision. The refractionist should then return to 38 degrees, where single binocular vision had originally been determined (Fig. 28), alternating back to 42, returning to 38, over to 34, back to 38, and so on. This procedure should be employed once a day just after meals for about five minutes, and repeated ten times, constantly striving for a slight reduction of prism power from day to day.

Effect of Muscular Exercise

This muscular treatment, or constructive exercising, should enable the patient to overcome his amount of four degrees in either direction in about a week. Hence in the case showing 38 degrees for single binocular vision, results may be looked for in about nine weeks —four degrees divided into 38 degrees. While the patient is undergoing the treatment, which is nothing more than the strengthening of the interni muscles or developing adduction, it is natural to believe that the amount of imbalance is likewise being conquered. This, however, is readily determined from time to

time by making the binocular muscle test with the phorometer and Maddox rod, as well as the duction chart test (Fig. 24), as previously outlined.

To fully appreciate the effect of this muscular treatment, the reader need only hold his head in a stationary position, casting his eyes several times from the extreme right to the extreme left, not failing to note the apparent muscular strain. On the other hand, with the aid of the Ski-optometer's rotating prisms, the refractionist not only has complete control of the patient's muscles at all times, but scientifically accomplishes muscular exercise without any tiresome strain, overcoming all possible exertion.

After the case in question has been reduced to 30 degrees, having no further use for the rotary prism, it may be removed from before the right eye and the same exercising procedure continued as before with the remaining left side rotary prism by reducing its power, until it is likewise down to zero.

Having reduced both prisms to zero, each prism should again be placed in position with zero graduations vertical and the prism indicator on upper zero. Both prisms should then be turned simultaneously about four degrees toward the nasal side of the patient, thus

tending to jointly force corresponding muscles of both eyes.

Home Treatment for Muscular Exercise—Square Prism Set Used in Conjunction With the Ski-Optometer

Where a patient is unable to call each day for this muscular treatment or exercise, the work will be greatly facilitated by employing a specially designed set of square prisms ranging in strength from ½ to 20 degrees for home treatment. As in the case previously cited, it is necessary to carefully instruct the patient that the interni muscles *must* be developed, hence prism base *out* with apex in must be employed. Attention should then be directed to a candle light, serving as a muscle testing spot of light and stationed in a semi-dark room at an approximate distance of twenty feet.

Having determined through the Ski-optometer the strength of the prism required after each office treatment, its equivalent should then be placed in a special square prism trial frame which permits rotation of the prism, although the patient is frequently taught to twirl the lens before the eye. This exercise may be continued for about five minutes each day.

The patient should also be instructed to call

at the end of each week, when the work may be checked by means of the Ski-optometer's rotary prisms, making the duction test as previously explained and outlined in Fig. 24. It is then possible to determine whether or not satisfactory results are being obtained. Otherwise the exercise should be abandoned.

Should the second method employed in the work of muscular imbalance not prove effective, the third method requiring the use of prisms would be next in routine.

Chapter XI

THIRD METHOD OF TREATMENT—PRISM LENSES

When and How Employed

AS stated in the preceding chapter, on ascertaining the failure of the second muscular treatment or method, prisms are employed for constant wear. When prism lenses are used, whether the case is exophoria or esophoria, or right or left hyperphoria, it is always safe to prescribe one-quarter degree prism for each degree of prism imbalance for each eye. For example, in a case of 6 degrees of esophoria, a prism of 1½ degree base out should be prescribed for each eye; or in 6 degrees of exophoria, employ the same amount of prism, but base in. In right hyperphoria, place the prism base down before the right eye and up before the left, and vice versa for left hyperphoria.

It is not always advisable, however, to allow the patient to wear the same degree of prism for any length of time. Many authorities suggest a constant change with the idea that a prism is nothing more than a crutch. Should the same degree be constantly worn, even though it afforded temporary relief, the eye would become accustomed to it and the pur-

pose of the prism entirely lost. Prisms should be prescribed with extreme care, their use being identical with that of dumb-bells, where weight is first increased to maximum and subsequently reduced, viz.:

Prism Reduction Method

Where prisms are prescribed, it is considered good practice to make a binocular muscle test and the duction test (Fig. 24) at the end of each three months' period, employing the phorometer, Maddox rod, and rotary prisms, as already explained.

If the condition shows any decrease, the prism degree should be proportionately decreased. For example, in the case originally showing 6 degrees of exophoria, one-quarter degree prism for each degree of imbalance was prescribed, or 1½ degree for each eye. If the same case subsequently indicated 4 degrees, only one degree for each eye should be prescribed—and so on, a gradual reduction of prism value being constantly sought.

Except in rare cases, prisms should not be prescribed with the base or apex at oblique angles, as the eye is rarely at rest with such a correction. An imbalance may be caused by a false condition in one rectus and a true imbalance in the other, giving one the impres-

sion that cyclophoria exists, as explained in a following chapter.

Having now employed the three methods, the refractionist can readily understand that a marked percentage of muscular imbalance cases may be directly benefited through the aid of the Ski-optometer. If these three methods of procedure fail, there is nothing left but the fourth and last method—that of operative procedure.

CHAPTER XII

A CONDENSATION OF PREVIOUS CHAPTERS ON THE PROCEDURE FOR MUSCLE TESTING WITH THE SKI-OPTOMETER

THE present chapter, intended for those desiring a synopsis or condensed summary of muscular imbalance work, should prove of the utmost assistance to the busy refractionist. Muscular imbalance work can be successfully conducted if the following routine is studied and memorized, with the Ski-optometer *constantly before the reader.* The chapters containing the corresponding figures and diagrams or illustrations will then be readily comprehended. It is also important to carefully note the captions under each diagram.

1. Without any testing lenses before patient's eyes, direct attention to a 20-foot distant muscle testing spot of light (Fig. 9).

2. Place phorometer handle vertically (Fig. 16).

Place red Maddox rod vertically (Fig. 15). Patient should see a white spot of light, and a red horizontal streak (Fig. 17).

Simply turn phorometer handle until horizontal streak bisects white spot of light. Pointer then indicates amount of deviation on red scale. Ignore cases less than 1° hyperphoria,

whether right or left designated by (R. H.—L. H.).

3. Place phorometer handle horizontally (Fig. 19).

Place red Maddox rod horizontally (Fig. 18). Patient should see a white spot of light and a vertical red streak (Fig. 20).

Simply turn phorometer handle until red streak bisects spot of light. Pointer indicates amount of deviation on white scale, whether esophoria or exophoria designated by (Es—Ex).

4. Ignore all exophoria cases, less than 3°.

Ignore all esophoria cases, less than 5°—except in children, ignore less than 3° of esophoria.

5. Always make the above or binocular muscle test—with phorometer and red Maddox before optical correction or (test for spheres and cylinders) and again after optical correction where case shows more than 1-3-5 rule, to determine whether muscles are aggravated or benefited.

6. In cases showing more than the 1-3-5 rule, shown in above No. 4, make monocular duction test first with rotary prism before patient's right eye,—then with rotary prism before left eye to find faulty muscle and determine which eye is affected.

7. To test adduction, prism base out is required. Rotary prism's red line or indicatoı should be rotated from zero outwardly. To test abduction, base in is required. Indicator should be rotated inwardly from zero (Fig. 22). Power of adduction as compared with abduction, is normally 3 to 1—usually rated 24 to 8.

8. To test superduction, base down is required. Rotary prism's line or indicator should be rotated downward from zero. To test subduction, base up is required. Indicator should be rotated upward from zero. Power of superduction as compared with subduction, is normally equal—usually rated 2 for each (Fig. 23).

9. Direct patient's attention to largest letter on distant chart, usually letter "E," rotating red line indicator of rotary prism outlined in above No. 7 and No. 8, until diplopia is first procured.

10. The use of a duction chart on a record card, quickly designates pull for each of four muscles (Fig. 24), illustrating an assumed case of—

1st—6D of Exophoria.

2nd—18° adduction (which must be developed to 24°).

3rd—Patient has a left weak internus.

11. Employ First Method—Optical Correction—to effect treatment.

12. Assuming a case of a child with 6° of esophoria—8° of right abduction and 2° left abduction indicating a left weak externus, prescribe a quarter dioptre increased plus spherical power for each degree of imbalance, thus adding+1.50D spherical to optical correction. This is the *first* method of treatment. This requires a thorough reading of Chapter IX on Treatment for Correcting Esophoria in Children and a careful study of the formula. For synopsis see Page 74.

FOUR METHODS OF TREATING AN IMBALANCE CASE WHEN THE PRECEDING ONE FAILS

1st—Optical correction;

2nd—Muscular exercise or treatment;

75% ARE CURABLE WITH FIRST AND SECOND METHODS.

3rd—Prisms;

5% ARE CURABLE WITH THIRD METHOD.

4th—Operation;

20% ARE CURABLE WITH FOURTH METHOD.

13. When first method of treatment fails, EMPLOY SECOND METHOD—Muscular Exercise—to effect treatment.

1st—Find degree of prism patient will ac-

cept to produce single binocular vision with optical correction on, placing both rotary prisms in position, handles horizontal, red line on 30° of temporal scale of each, giving total value to 60° (Fig. 26a and b).

2nd—Also place red Maddox rod before patient's eye (rods horizontal) (Fig. 18), calling patient's attention to usual muscle testing spot of light.

3rd—Reduce prism before good eye until red streak appears, noting degree (which we assume shows 42° the combined total value of both prisms) slowly continue to decrease prism until streak bisects spot. Assume this shows total of 38°. Either side of 38° in excess of 4° (38 to 42) produces diplopia. Prisms must only be rotated from 38° to 42° back to 38° over to 34°—back to 38° over to 42°—back again to 38° and so on—exercise to be continued daily ten times for five minutes (Fig. 28).

4th—At end of each week, duction test should again be made. Duction chart should show a tendency to reduce exophoria by a gradual building up of adduction, approximately one week is usually sufficient to teach patient to hold streak within the spot (between 38° and 42°). Exercise to be continued until both prisms are worked down to

zero. Exercise tends to teach patient how to establish same image on each fovea or retina at same time.

5th—If patient is unable to call daily for treatment, employ home treatment. (Read "Home Treatment for Muscular Exercising," Page 82).

Employ THIRD METHOD—Use of Prisms for Constant Wear to effect treatment.

PRISMS

1st. Where a case cannot be reduced through use of first two methods, as for example in a case of 6° of exophoria, prescribe 1/4 of amount of imbalance ($\frac{1}{4} \times 6 = 1\frac{1}{2}°$) for each eye—base in—or esophoria base out, hyperphoria base up on eye affected.

2nd. Advise patient to call every three months and make duction test (Fig. 24). If no improvement in condition, after wearing prisms six months, operative means is suggested.

Assume a case is benefited; reduce prism power according to rule; 1/4D prism for each degree of imbalance.

CYCLOPHORIA

This work being of a technical nature, it is deemed best for the reader to study Chapter XIII and XIV.

Chapter XIII

CYCLOPHORIA

Made with Maddox Rods and Rotary Prisms

CYCLOPHORIA, a condition affecting the oblique muscles of the eye, is caused by its rotation. It is detected in the following manner by the combined use of the red and white Maddox rods and the rotary prism.

Fig. 29—Position of rotary prism for producing diplopia in testing cyclophoria with prism placed at 8° base up.

Darken the room and direct the patient's attention to the usual muscle-testing spot of light, located approximately twenty feet away and on a direct plane with the patient's eye. The optical correction, if one is required, should always be left in place—just as in making other previously described muscle tests.

The rotary prism should then be brought before the patient's right eye with the handle-pointing upward and with zero graduations horizontal. The indicator or red line should then be rotated upward from zero to eight upon the prism scale, creating the equivalent of a prism of 8 diopters with base up (Fig. 29). This normally caused diplopia, although in some cases it may be necessary to place the prism at 10 or 12 degrees before diplopia is produced.

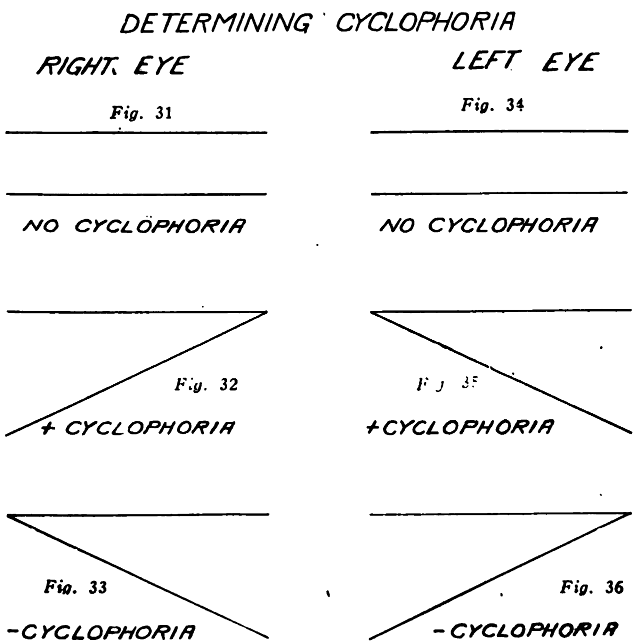
A B

Fig. 30—(A. and B.)—First position of both Maddox rods used in conjunction with Fig. 29 for determining cyclophoria.

The red Maddox rod should then be brought into operative position before the patient's left eye (Fig. 30a) and the white Maddox rod before the patient's right eye, (Fig. 30b) setting each one so that the rods lie in

a vertical position with their white line on the large red zero (0).

The patient should now see two separate and distinct streaks of light, one appearing below the other.



Figs. 31-36—Diagram showing how streaks appear to patient, as produced by the Maddox rods in testing for cyclophoria.

Should there be no cyclophoria of the right eye, the streaks will appear in a horizontai plane parallel to each other (Fig. 31).

Should the red streak appear horizontally to the left eye, and the white streak seen by the right eye appear at an angle therewith, cyclophoria of the right eye would be indictated (Fig. 32).

In brief, should the white streak dip towards the patient's left side, the case would be one of right *plus* cyclophoria (Fig. 32); whereas right *minus* cyclophoria would be indicated should the white streak dip to the patient's *right* side (Fig. 33).

Next, setting the rotary prism of 8 degrees, placed base up before the patient's left eye, the *red* streak should appear below the *white* one. Should the two streaks appear horizontally, parallel with each other, there would be *no* cyclophoria of the left eye (Fig. 34).

If, however, the upper or white streak should appear horizontal, and the lower or red streak at an angle therewith dipping toward the patient's *right* side, the left eye would be cyclophoric and the case would be one of left *plus* cyclophoria, as the chart indicates (Fig. 35).

Should the red streak dip in toward the patient's *left* side, left-*minus* cylophoria would be designated (Fig. 36).

The patient would instinctively describe, with pointed finger and hand motion, the posi-

tion of the "dipping" line just as one would describe a spiral staircase. Should this test determine that no cyclophoria exists in either eye, there would be no necessity for further tests.

Some authorities claim that both Maddox rods should be of the same color, so as to more readily assist the patient to fuse the two objects. If the reader so desires, he can readily place a red lens from the trial case in the forward cell of the instrument.

The characters *plus* and *minus* in cyclophoria merely refer to *plus* as signifying a tendency toward the *temporal* side; *minus* indicating a tendency toward the *nasal* side. This has no bearing on "convex" and "concave," which are frequently designated as "plus" and "minus."

The test for cyclophoria is particularly essential, proving of utmost importance where the patient requires an astigmatic correction with the cylinder axis in oblique meridian. The case should then be investigated in every instance by making a thorough and separate test of each eye for cyclophoria.

In a case where cyclophoria is determined, the trouble may be caused by the functioning of *other* muscles, through the drain of nerve

force, thus disturbing the harmony of *every* muscle action.

Cyclophoria is frequently caused by an imbalance of two recti, giving an oblique pull. In most cases, it is merely necessary to release the torsion, as described in the following chapter.

CHAPTER XIV

CYCLODUCTION TEST

MADE WITH THE COMBINED USE OF THE TWO MADDOX RODS

HAVING determined that cyclophoria exists, as previously outlined, the next step would be to make a cycloduction test, or a test of the oblique muscles individually. Maddox rods, both red and white, should be placed in position with the rods horizontal—the plus and minus sign at 90 degrees on the scale (Fig. 37). The patient's attention should be directed to the usual muscle-testing spot of light, when a vertical band of light will appear to the patient, as shown in Fig. 38.

A B

Fig. 37—(A. and B.)—Primary position of combined use of both Maddox rods for determining cycloduction test.

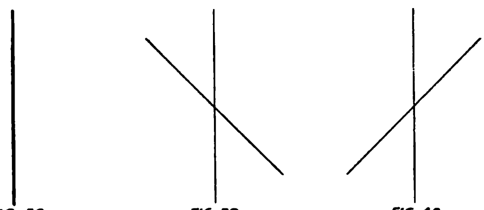


FIG. 38 NORMAL

FIG. 39 RIGHT +CYCLODUCTION LEFT -CYCLODUCTION

FIG. 40 RIGHT -CYCLODUCTION LEFT +CYCLODUCTION

Figs. 38-40—Diagram showing position of streaks produced by Maddox rods as they appear to patients in making cycloduction tests.

To measure the duction range of the inferior oblique of the right eye, it is merely necessary to slowly rotate the Maddox rod before the right eye upward at its nasal end to the point where the band of light breaks so as to resemble a letter "X". This gives in degrees the amount of right plus cycloduction, as indicated on the temporal scale, when it will appear to the patient, as shown in Fig. 39.

The Maddox rod should then be restored to its original position, with the plus and minus on the 90 degree line of the scale (Fig. 37), and rotated upward at the temporal end until it again takes the form of the letter "X." (Fig. 40.) The position of the indicator will now denote the amount of right minus cycloduction, or duction range of the right superior oblique muscles. Having determined the duction

range of the oblique muscles of the patient's right eye, both Maddox rods should be placed in original position with rods horizontal and plus and minus sign on 90° of scale, as shown in Fig. 37.

The Maddox rod before the left eye is then employed exactly in the same manner as before when the test for the right eye was made. A plus cycloduction of the left eye would be indicated, as shown in Fig. 40, while a minus cycloduction of the left eye would appear to the patient, as shown in Fig. 39.

By recording a comparison of each eye, as explained, it will be found that the range of duction usually averages five to twenty degrees on either side of the 90 degree line, as indicated on the scale surrounding the Maddox rods.

It will be recalled that cyclophoria was only to be looked for in oblique astigmatic cases. It is frequently possible to correct the patient's trouble, by changing the axis of the cylinder, before one or both eyes, a minus cycloduction signifying a change of axis towards 180° while a plus toward 90°, according to the amount lacking in full duction power. It is also well to exercise the oblique muscles through a rotation of the Maddox rod before the affected eye, whether it be one or both that is lacking

in full duction power, until the required amount is reached to equal its fellow member.

For a more exhaustive treatise the author suggests a reading of Dr. Savage's work on the subject.

Treatment for Cyclophoria

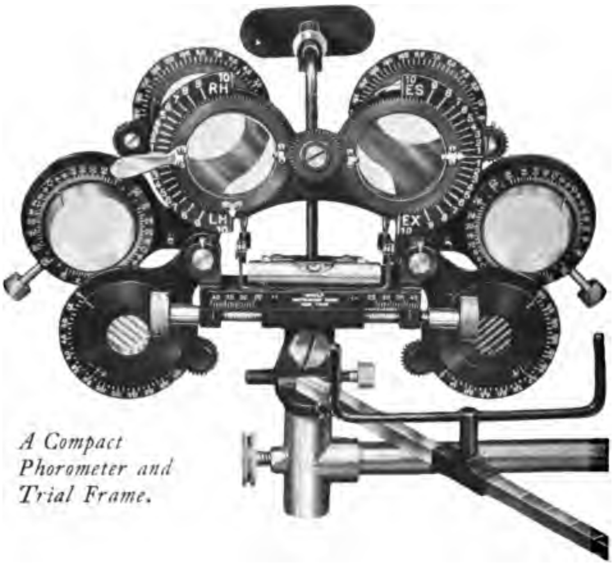
As previously stated, it often proves of great benefit to employ a muscular exercise where a patient has an existing cyclophoria of either one or both eyes, results derivable through the exercise of the recti muscles having been previously detailed.

To exercise the oblique muscles of the right eye, *both* Maddox rods should be placed in the original position employed for making cycloduction test, as previously explained (Fig. 37). This causes the patient to see but *one* band or vertical streak (Fig. 38).

The Maddox rod, placed before the right eye, should be slowly rotated inward from ninety degrees to a point on the scale where the single streak of light breaks, when it should again be returned to ninety degrees. This causes a contraction and relaxation of the muscles in the form of an exercise and should be repeated ten times—about five minutes each day. By employing the Maddox rod before

the left eye in precisely the same manner, its oblique muscles will be exercised.

To determine whether or not this form of exercise is beneficial to the patient, the weekly cycloduction test, as previously described, should be made and compared with the original findings.



A Compact
Phorometer and
Trial Frame.

SKI-OPTOMETER MODEL 235

For Testing and Correcting Muscular Imbalance—
Providing a Comfortable Form of Trial Frame.

Chapter XV

MOVEMENTS OF THE EYEBALLS AND THEIR ANOMALIES

AFTER a careful study of the foregoing chapters, the refractionist may desire *further* knowledge concerning muscular imbalance—a matter in which the Ski-optometer plays an exceptionally important part.

It should be remembered that it is only the general utility of the instrument, *plus* one's knowledge of refraction and individual diagnosis that enables the refractionist to attain maximum efficiency in every examination, a fact which largely accounts for the following chapter.

Monocular Fixation

When we view an object *directly,* so that it appears to be more distinct than surrounding objects, we are said to "fix" or "fixate" it.

As the fovea is normally the most sensitive part of the retina, affording by far the most distinct vision, "fixation," in the great majority of cases, is so performed that the image of the object that is "fixated" falls upon the fovea of the eye that is "fixing." This is known as central or muscular "fixation."

When central vision is absent, however, the patient is compelled to see with a portion of

the retina *outside* of the fovea. The eye must then be so directed as to cause the image of the object to fall on this outlying portion of the retina. This is termed "eccentric fixation," and usually denotes that vision is exceptionally poor.

The ability to "fix" is apparently acquired in early infancy by constant practice in looking at objects. Any marked interference with vision, particularly with central vision—present at birth or soon thereafter—will tend to prevent the acquisition of this ability, and in *extreme* cases the eye does not learn to "fix" at all, but aimlessly wanders in all directions.

Binocular Fixation

We habitually use the eyes together, fixating with both at once; that is, we direct the eyes in such a way that the image of the object to which the attention is directed falls on the fovea of each eye.

Where both eyes are accurately directed to an object at which one or both are looking, the condition is known as "binocular fixation," which is commonly understood to mean that *both eyes are straight.*

The ability to produce and maintain binocular fixation—to keep both eyes directly straight—is acquired early in life. The im-

pulse to maintain it grows with exercise, and soon becomes so strong that after the age of infancy binocular fixation is present in the great majority of persons, and in most of them is present all the time.

Binocular fixation must be distinguished through three conditions — *orthophoria, heterophoria* and *squint.*

ORTHOPHORIA

This is the condition in which both eyes look straight at the same object, whether both see it or not. There is not the slightest tendency of deviation.

HETEROPHORIA

This is the condition in which both eyes keep looking straight at the same object so long as both *see* it; but as soon as one eye is excluded from vision (as by a screen) that eye deviates. This is then a tendency of deviation which is strong enough to become manifest when either eye is covered, but which is abolished or overcome by the compelling impulse of binocular fixation as soon as both eyes are used for seeing. A heterophoria thus produces a maximum deviation. The deviation is also said to be *latent,* since it is absent under ordinary conditions and is brought to light

only under special conditions. A common though improper term for heterophoria is "insufficiency."

Squint

Squint is the condition in which there is so great a tendency to deviation that even when both eyes are uncovered, one deviates and only one "fixes." It differs, therefore, from heterophoria in that the deviation it produces is obvious under ordinary conditions.

Squint is also called strabismus, or heterotropia. In other words, in orthophoria there is binocular fixation *all the time* and under all conditions; in heterophoria it is present only when the two eyes are uncovered, so that both see the object looked at; while in squint it is not present at all.

Or, in still plainer terms, in orthophoria both eyes are straight all the time; in heterophoria both are straight, but only so long as both are uncovered; and in squint only one eye is straight, no matter whether both eyes are uncovered or not.

In squint, while binocular fixation is altogether absent, the ability to perform monocular fixation is almost always preserved; i.e., the squinting eye will "fix" at once if the other eye is covered. It is only when there is

marked amblyopia, particularly as the result of a central scotoma (or spot on the cornea in the line of vision) that the squinting eye loses its power to fix at all, and wanders uncertainly about, receiving impressions now on one, now on another portion of the retina.

The term imbalance is often used to denote the two conditions opposed to orthophoria; i.e., to denote collectively heterophoria and squint.

Varieties of Heterophoria and Squint

1. *Classification According to Direction of Deviating Eye*: Heterophoria and squint may be classified according to the direction assumed by the deviating eye. Thus we have the following varieties of heterophoria:

Heterophoria

Lateral Deviations

Either eye deviates
- In, or toward the nose ....Esophoria
- Out, or toward the temple ....Exophoria

Vertical Deviations

The right eye goes up and the left down.........Right Hyperphoria
The left eye goes up and the right down..........Left Hyperphoria

In rare cases of vertical heterophoria, each eye has either an upward tendency (anophoria) or a downward tendency (cataphoria). These cases must not be confused with anatropia and catatropia. In anaphoria and cato-

phoria, there is binocular fixation when both eyes are uncovered, while in anatropia and catatropia *one* of the eyes squints. This shows the following squint condition:

Squint

Lateral Squint

The deviating eye turns in, or toward the nose:
  Esotropia (Strabismus convergens—Convergent Squint)
The deviating eye turns out or toward the temple:
  Exotropia (Strabismus divergens—Divergent Squint)

Vertical Squint

The deviating eye turns up:
  Hypertropia (Strabismus sursumvergens) (Right or left)
The deviating eye turns down:
  Hypotropia (Strabismus deorsumvergens) (Right or left)

In addition to these lateral and vertical deviations, conditions exist in which the vertical meridian of one eye, instead of maintaining its parallelism with the vertical meridian of the other, either forms (or tends to form) an angle with it (cyclotropia), but is kept in position through muscular effort (cyclophoria.)

Cyclotropia is usually due to paralysis of one of the ocular muscles, causing the vertical meridian of the affected eye to be tilted out or toward the temple (extorsion) or in toward the nose (intorsion). A tilting of the vertical meridian toward the right is also called dextrotorsion (or positive declination); and to the left, levotorsion or negative declination.

2. *Constant, Intermittent and Periodic Deviations*: A deviation, whether squint or heterophoria, may be present at all times (constant), or occasionally present and occasionally absent (intermittent). In this case we may have heterophoria alternating with orthophoria, or heterophoria alternating with squint; or squint alternating with orthophoria. We also find variations such as a squint for near and a heterophoria or orthophoria for distance; or a heterophoria for near and orthophoria for distance; or a constant squint for near and an intermittent squint for distance, etc. Again, a deviation may be periodic, in that its amount for distance may greatly exceed that for near, or vice versa.

Opposed to a periodic deviation is one which is present, and in about equal amount, both for distance and near. Such a deviation, whether squint or heterophoria, is called "continuous."

3. *Alternating and Uniocular Squint*: An alternating squint is one in which when both eyes are uncovered, so that both have a chance to "fix"; sometimes the right eye will deviate, sometimes the left. In uniocular (less properly monocular) squint, under the same conditions, one eye, either the right or the left, always "fixes" and the other always deviates.

A TYPICAL REFRACTION ROOM—THE WOOLF SANITARY ALL-METAL EQUIPMENT

Installation comprising: Ophthalmic Chair, complete with Skioptometer, Test Letter Cabinet, Asceptic Trial Case Cabinet. Muscle Testing and Skioscopic Lamp, Ophthalmometer, Perimeter. Adjustable Tables, Adjustable Stool.

A uniocular squint is denoted as right or left, according to whether it is the right or left eye which deviates.

4. *Comitant and Non-Comitant Deviations*: In some varieties of heterophoria and squint, the amount of deviation is the same in all directions of the gaze, so that the angle between the visual line of one eye and that of the other remains the same, no matter which way the eyes are turned. Such deviations are called comitant or non-comitant, because one eye accompanies and keeps pace with the other in all its movements. In other cases, the deviation changes as the eyes are moved in different directions, so that the angle between the two visual lines constantly varies. Such deviations are termed concomitant. Usually in a non-comitant squint the angle of deviation increases in a regular way as the eyes are moved in one direction and decreases as they move in the direction opposite.

In cases of long standing, however, the squinting eye, particularly when very amblyopic, wanders in an uncertain way and apparently quite without reference to the movements of the other eye.

CHAPTER XVI

LAW OF PROJECTION

THE movements of the eye are designed primarily to effect fixation—that is, to bring upon the macula the image of the object that we wish to look at. When this has been accomplished, we know as a result of long experience, the direction of the object looked at and also direction of other neighboring objects. This knowledge is doubtless afforded us, in part, by our muscle sense. Thus we know that an object, A, is straight in front of us because we can see it sharply without moving either the head or the eyes from the position of rest or equilibrium; and we know that an object, B, is on the right of us because to see it sharply we have to move either the head or the eyes to the right, thus altering the muscular condition from one of rest to one of tension. But without moving either head or eye, we also know, while still looking at A, that B is to the right, for the image of B is then formed on a portion of the retina situated to the left of the macula. From long experience we also know that an image so situated means an object placed on our right. Moreover, the farther to the left of the macula the image B is, the farther to the right do we judge B itself to be.

Similarly, if B is so placed that its image falls below the macula, we then know B itself is really above A, which forms its image on the macula; and if the image of B is above the macula, we know that B itself is below A.

The table on page 116 is suggested as a guide in cases of muscular imbalance:

Suppression of Image

All deviations should be and probably are primarily associated with diplopia. Yet in the great majority of cases of established squint, especially convergent squint, there is no double vision. This is due to the mental suppression of the image by the squinting eye. In such cases all attempts to evoke diplopia by our tests may be futile, the patient not appreciating the presence of double images even when they are widely separated by prisms. Moreover, this suppression usually persists after the squint is cured, so that even though there are two retinal images of the same object, the mind perceives but *one* and ignores the *other,* just as though it were not present. In this case there is no true stereoscopic, or solid, vision.

Monocular Diplopia

Binocular diplopia, due to deviation of the eyes or to prisms, must be distinguished from

TABLE OF DIPLOPIA

	Name of diplopia	Image of right eye as compared with that of the left is	CAUSED BY		CORRECTED BY	
			(1) By a natural deviation of	(2) Artificially by a prism placed, base	(1) Turning	(2) Prism placed with base
Lateral	Homonymous	On the right	Either eye inward (esophoria, esotropia.)	In before either eye.	Both eyes outward (divergence.)	Out before either eye.
Lateral	Heteronymous (or crossed)	On the left	Either eye outward (exophoria, exotropia.)	Out before either eye.	Both eyes inward (convergence.)	In before either eye.
Vertical	Right	Below	Right eye up or left eye down (right hyperphoria, right hypertropia, left hypotropia.)	Up before right eye, down before left eye.	Right eye down and left eye up (left supravergence.)	Down before right eye or up before left eye.
Vertical	Left	Above	Right eye down or left eye up (left hyperphoria, left hypertropia, right hypotropia.)	Down before right eye, up before left eye.	Right eye up and left eye down (right supravergence.)	Up before right eye or down before left.

monocular diplopia, or the condition in which the patient sees double with one eye alone. This occurs as the result of astigmatism, plus spherical aberration and other conditions found occasionally in squint. It can readily be differentiated by the fact that binocular diplopia disappears when the patient shuts either eye; while monocular diplopia, of course, does not.

Movement of Each Eye Singly

The movements of each eye individually are effected as follows:

The external rectus moves the eye directly outward; the internal rectus, directly inward.

The primary action of the superior rectus is to raise the eye. Because of the way in which the muscles run, obliquely from within outward, its lifting action increases when the eye is abducted and diminishes to little or nothing when the eye is adducted.

The inferior rectus carries the eye down. Owing to the oblique direction of the muscle, its depressing action increases as the eye is abducted and decreases to zero as the eye is adducted.

The inferior oblique is inserted back of the equator of the eye. Hence it pulls the back part of the eye down and consequently throws

the front part up. It is thus an elevator of the eye, reinforcing the action of the superior rectus. Owing to the way in which it runs, from the front backward and outward, its elevating action is greatest when the eye is adducted, and diminishes to little or nothing when the eye is abducted.

The superior oblique, so far as its action on the eyeball is concerned, may be regarded as arising from the trochlea. From this point it runs backward and outward and is inserted back of the equator of the eye. It there pulls up the back part of the eye and consequently throws the front part down. It is thus a depressor, reinforcing the action of the inferior rectus. Owing to the oblique way in which it runs, its depressing action is greatest when the eye is adducted, and diminishes to little or nothing when the eye is abducted.

Subsidiary Actions

Besides these actions, rightly regarded as the main action of the ocular muscles, there are various subsidiary actions, due to the oblique way in which the superior and inferior recti and the two obliques run. Thus, both the superior and inferior recti adduct the eye, their action being most pronounced when the eye is already adducted. The two

obliques, on the other hand, abduct the eye and do so most effectively when the eye is already abducted.

The superior rectus and superior oblique rotate the top of the vertical meridian of the eye inward (intorsion); while the inferior oblique and inferior rectus rotate it outward (extorsion). The superior and inferior recti act thus on the vertical meridian mainly when the eye is adducted; the oblique, on the other hand, when the eye is abducted.

Hence the eye is adducted by the internal rectus, assisted toward the end of its course by the superior and inferior recti. It is abducted by the external rectus, assisted toward the end of its course by the two obliques. It is carried straight up by the superior rectus and inferior oblique, up and out by the superior rectus and external rectus (the inferior oblique helping to carry it out, but not up; and in, mainly by the inferior oblique and internal rectus). The superior rectus assists in carrying it in, but hardly up at all.

The eye is likewise carried straight down by the inferior rectus and the superior oblique; down and out by the inferior and external recti, and down and in by the superior oblique and internal recti.

Field of Action of Muscles

As will be seen, each muscle acts most energetically in some special direction of the gaze, termed field of action of that particular muscle; thus the external rectus acts most powerfully when the eye is directed outward, and acts little or not at all when the eye is directed inward, except by purely passive traction. Likewise the superior rectus acts mainly when the eye is directed down. Furthermore, its action is limited to the upper and outer field; for in the upper and inner field elevation is performed chiefly by the inferior oblique.

This is also true of all the other muscles.

Direction of the Gaze

There are six cardinal directions of the gaze, each corresponding to the field of action of one of the six ocular muscles as follows:

Cardinal Direction:	Muscles Specially Active:
Straight out	External rectus
Straight in	Internal rectus
Up and out	Superior rectus (as an elevator)
Up and in	Inferior oblique (as an elevator)
Down and out	Inferior rectus (as a depressor)
Down and in	Superior oblique (as a depressor)

It is to be noted that the action of each muscle does not absolutely *stop* at the middle line, but extends somewhat beyond it. Thus the action of the right externus extends not only

throughout the whole right half of the field of vision, but also some fifteen to twenty degrees to the left of the median line; and that of the superior rectus extends not only above the horizontal plane but also somewhat below.

Primary Position—Field of Fixation

Under normal conditions, when the head is erect and the eye is directed straight forward —that is, when its line of sight is perpendicular to the line joining the centres of rotation of the two eyes in the horizontal plane—the muscles are all balanced. This is called "the position of equilibrium" or the primary position. It is this position which must be assumed by the patient in conducting tests for balance of the muscles.

From the primary position, the eye may make excursions in every direction so that the patient can look at a whole series of objects in succession without moving the head. This portion of space, occupied by all the objects that may thus be seen directly by moving the eye without moving the head, is called "the field of fixation."

Binocular Movements

While either eye alone may move in all possible directions, one cannot move *independently* of the other eye. Under ordinary circum-

stances, those movements only are possible which are regularly required to subserve binocular vision, hence, binocular single vision, as well. These movements are as follows:

Parallel Movements

When one eye looks at a distant object the other is also directed to it, so that the lines of sight of the two eyes are parallel; if the distant object is moved about, the lines remain parallel, one moving as fast and as far as the other. These parallel movements of the two eyes are executed with considerable freedom in all directions, either eye being able to move readily to the right, left, up, down, or obliquely, provided the other eye moves precisely with it.

In executing any parallel movement, each eye is acted upon by at least three and sometimes by as many as five muscles. At times, but one of these muscles is required to produce any *great* movement of the eye, the others simply serving to steady it in its course. Thus when we look up to the right, although there are five muscles really acting upon each eye, the right eye is moved mainly by the *external* rectus and the left eye by the *internal* rectus.

Similarly, when we look up and to the right, although other muscles take part, the superior rectus is the chief muscle that moves the right

eye up, and the external rectus the chief one that moves it to the right; while for the left eye the inferior oblique and the internal rectus are the efficient muscles.

A careful study of the action of the individual muscles will make it clear that these facts hold good for each of the cardinal directions of the gaze.

Furthermore, if we attentively consider the action of the twelve muscles moving the two eyes, we see that they may be divided into three groups, *viz;* four *lateral rotators,* four *elevators* and four *depressors.*

LATERAL ROTATORS

Right rotators L. Internal rectus R. External rectus	to	Left rotators R. Internal rectus L. External rectus

ELEVATORS

Right-handed elevators (acting mainly when the eyes are directed to the right) R. Superior rectus L. Inferior oblique	to	Left-handed elevators (acting mainly when the eyes are directed to the left) R. Inferior oblique L. Superior rectus

DEPRESSORS

Right-handed depressors (acting mainly when the eyes are directed to the right) R. Inferior oblique L. Superior oblique	to	Left-handed depressors (acting mainly when the eyes are directed to the left) R. Superior oblique L. Inferior rectus.

Each group, it will be seen, comprises *two* pairs of muscles; one pair acting solely when

the eyes are directed to the right, the other when they are directed to the left. It will further be noted that of the two muscles constituting any one pair, one is situated in the right eye, the other in the left.

Eye Associates

The muscles forming any one pair are called associates. Any two associates acting together will move their respective eyes in precisely the same direction and to the same extent. Thus the right superior rectus moves the eye up to the left and rotates its vertical meridian to the left; and its associate, the left inferior oblique, moves its eye up to the left and rotates its vertical meridian to the left. This likewise applies to each of the other five groups of associates.

If one eye fails to keep pace with the other in executing parallel movements, diplopia ensues. If the eyes are moved in all directions and the point noted where the patient just begins to see double, we *delimit* the field of binocular single vision.

Normally, however, the two eyes maintain parallelism to the very limit of their excursion, so that diplopia occurs only at the extreme periphery of the field of vision, if at all. In fact, the field of binocular single vision

usually extends not less than 40 degrees from the primary position in every direction.

Each of the various parallel movements of the eye appear to be governed by a distinct nerve mechanism, there being one centre for movements to the right, one for movements to the left, one for movements up, etc.

Movements of Convergence

In order to see an object at a nearby point, the eyes have to converge—a movement affected by a simultaneous and equal contraction of both internal recti. This movement may be combined with a vertical, lateral or oblique parallel movement. Thus, when we wish to look at a near object situated twenty degrees to our right, we first turn both eyes twenty degrees to the right, then converge both equally, turning the left a little more to the right and the right a little back toward the left.

Convergence is governed by a distinct mechanism of the nerves, the source of which has not been determined.

Movements of Divergence

In passing from a position of convergence to a position of parallelism, the lines of sight separate or diverge. This movement of diver-

gence is a simultaneous, equal contraction of both externi; or, probably, of both actions combined. The eyes may even diverge somewhat beyond parallelism, as in overcoming prisms, base in, when looking at a distant object.

Vertical Divergence

The amount by which the lines of sight can separate in a vertical direction is very limited—at most but one or two degrees.

Orthophoria

The term orthophoria is used to denote an absolutely normal balance of the extrinsic muscles, just as the term emmetropia denotes a normal refractive condition. They are equally rare.

Heterophoria

The term heterophoria includes all those conditions in which there is a tendency to depart from normal balance, but which nature is able to compensate for; while the term also includes the conditions in which nature has been unequal to the task and an actual turning or squint has occurred.

Subdivisions

The subdivisions of these terms at first reading appear complicated, but prove simple

enough on closer study, indicating only the direction of the turning or tendency to turn. For instance:

Esophoria signifies *inward* tendency
Exophoria signifies *outward* tendency.
Hyperphoria signifies *upward* tendency.
Hypophoria signifies *downward* tendency.
Cyclophoria signifies *tendency* to torsion.
Esotropia signifies *inward* turning.
Exotropia signifies *outward* turning.
Hypertropia signifies *upward* turning.
Hypotropia signifies *downward* turning.
Cyclotropia signifies *actual* torsion.

Combinations are describable in similar terms. A tendency of the right eye to turn up and inward, is a "right hyperesophoria"; the left eye to turn down and out, a "left hyperexophoria," etc. Tendencies of both eyes together are denoted by the terms which follow:

Anaphoria signifies an *upward* tendency.
Kataphoria signifies a *downward* tendency.
Dextrophoria signifies a *right* tendency.
Laevophoria signifies a *left* tendency.

CHAPTER XVII

SYMPTOMS OF HETEROPHORIA

THESE depend on the kind of error present as well as the degree and widely vary. In general, they may be said to fall into three classes—(1) defective vision, (2) pain of greater or less degree—(3) reflex symptoms.

Defective Vision. The first class may be present, even though each eye has a normal visual acuity; since, even when compensation is very good, the brain gets the impression of two objects, nearly, though not quite fused; and vision may be considerably worse with both eyes together than with either eye singly.

When compensation is considerably impaired, the diplopia becomes more and more persistent, till the brain finally makes choice of one image as more satisfactory, entirely suppressing the other. Visual acuity may not suffer in either eye; but vision being no longer binocular, everything is seen in the flat, the judgments of depth and distance being regularly more or less defective. While this is a tremendous disadvantage in many occupations, people gradually and not infrequently become accustomed to these visual defects and are not conscious of the handicap.

Pain. It is quite different with the second set of symptoms, which are always accompanied with pain. In fact, the character of the subjective symptoms in refractive errors and muscular imbalance is so similar that it is practically impossible to differentiate in many cases.

In muscular asthenopia, however, in addition to becoming easily tired, the patient often complains that letters seem to jump or run together or he may contend that he sees double for an instant; or again that he can "feel his eyes turn" involuntarily in their sockets. These pains or conditions are sometimes present only during actual *use* of the eyes. At other times they persist for hours. In some cases, after days or weeks of overstimulation, an explosion in migraine form occurs at irregular intervals. This condition often lasts a day or two.

Reflex Symptoms. In the third and last case, there are other reflex symptoms—such as dizziness, nausea, fainting, indigestion, insomnia and pains in other portions of the body—sometimes stimulating organic diseases.

The possibility of heterophoria as a factor in chorea, migraine, neurasthenia and other diseases which may be primarily due to unstable nerves, equilibrium is not to be forgot-

ten. It is a notable fact that when the fusion compensation fails so completely that one image is entirely suppressed, or the diplopia is so great as to be overlooked, the symptoms often cease entirely.

Treatment

The treatment of heterophoria depends on a careful study of each individual case, but it cannot be too strongly emphasized that in the great majority of cases the subjective symptoms disappear after a full correction of the refraction is made.

In many cases, if the visual acuity in each eye be made normal, the fusion impulse alone will be sufficient to restore compensation.

Many cases of esophoria result from overstimulation of the centers for convergence and accomodation, made necessary by hyperopia and astigmatism, entirely disappearing when glasses abolish the need of accomodation. Cases of exophoria are sometimes due to the abnormal relaxation of accomodation and convergence which secures the best distant vision in myopia. Likewise the correction of myopia, by increasing the far point, may diminish the amount of convergence necessary for near vision.

Prisms for constant use are often prescribed, so placed as to help the weak muscles and counteract the strong. For instance, in esophoria we find the prism which, base in, will produce orthophoria for distance and prescribe a quarter of it, base in, before each eye. While this is very successful in some cases, the tendency in others is for the externus to increase slightly from constant exercise in overcoming the prism, while the internus decreases in proportion to the amount of work of which it is relieved. Prisms for permanent use are very beneficial in vertical deviations, since when the images are brought on the same level they require much less effort to secure fusion; and when prescribed base up or down, the effect secured is commonly an unchanging one.

We sometimes take advantage of this tendency when we prescribe for constant use weak prisms with the apex over the weak muscle, which gradually becomes strong from the exercise of overcoming it. This plan is effective only in patients who have a strong fusion impulse, and the prism selected must be weak enough to be easily overcome. We can accomplish the same effect by decentering the patient's refraction lenses.

For instance, a convex lens so placed that

the visual line passes the reverse will be the case if the lens is concave. The amount of prismatic action depends on the strength of the lens and the amount of decentering, the rule being that every centimeter of displacement causes as many prism dioptres as there are dioptres in that meridian of the lens. Thus +1 sphere, or cylinder axis 90, decentered one centimeter outward, is equivalent to adding a one degree prism dioptre lens, base out.

Destrophoria and Laevophoria

These are terms denoting a condition in which both eyes are capable of abnormal rotating toward the right or left, as the case may be. The movement in the opposite direction is most common. The patient can often rotate his eyes 60 degrees toward the right, and to perhaps only 40 degrees to the left. His position of rest is parallel with his visual lines, but to the *right,* in looking at objects directly in front, he is much more comfortable with his head turned slightly to the left.

It is difficult to account for, except on the theory that definite movement of the eyes is rather to the right than to the left in most occupations. The position of the paper in writing at a desk tends toward dextrophoria; in reading, we move our eyes steadily from

left to right and then begin a new line by a single brief movement to the left; the things that a man uses most—whether he be laborer or student—are kept within reach of the right hand, and in referring to them the eyes are constantly turned toward the right.

However, when these conditions result from other imbalances, they must be treated more carefully. For instance, a patient whose right internus is paralysed or congenitally defective on looking to the left, has a cross diplopia which vanishes to the right; as a result, he soon assumes a habit of carrying his head in this position. Ordinarily, this will cause no discomfort; but if the left internus is so weak that it cannot follow the right externus to its position of greatest ease, the visual lines are evidently different and the case must be treated as an exophoria.

If, on the other hand, the *left* internus overbalances the right externus, the condition is an esophoria and must be treated as such.

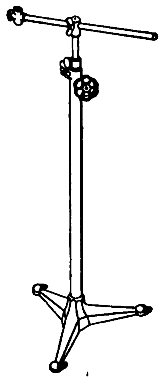
Similar reasoning applies to the conditions known as Anaphoria and Kataphoria, in which the visual lines are parallel to each other but directed up or down with regard to the horizontal plane of the body.

In the first, owing to congenital abnormalities, the eyes usually tend upward and the in-

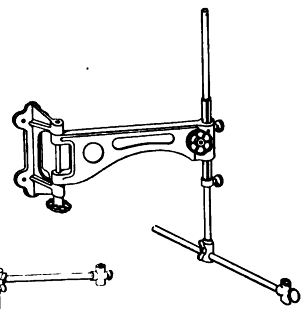
dividual must go about with his chin on his chest, so that his eyes may look in front and yet remain in the position of rest. In the second, the chin is held in the air and the body arched backward.

But, unless extreme, neither of these conditions causes more than cosmetic difficulty and both should be undisturbed owing to the extreme difficulty of securing the same operative effect on both eyes. Suitable prisms are much more likely to be beneficial.

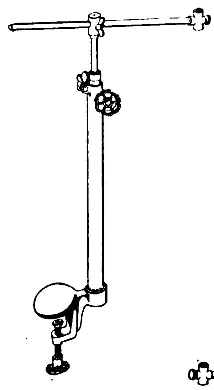
Supports for Holding The Ski-optometer



Floor Stand

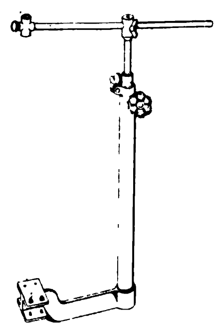


Wall Bracket



Chair Clamp

Choice may be made from any of the above. The Wall Bracket is recommended, unless refractionist is provided with a specialist's chair, to which the Chair Attachment with Upright may be attached.



Chair Attachment with Upright

NAME	DATE DUE